TECHNOLOGY DEPT.

# TECHNOLOGY REVIEW

November 1949

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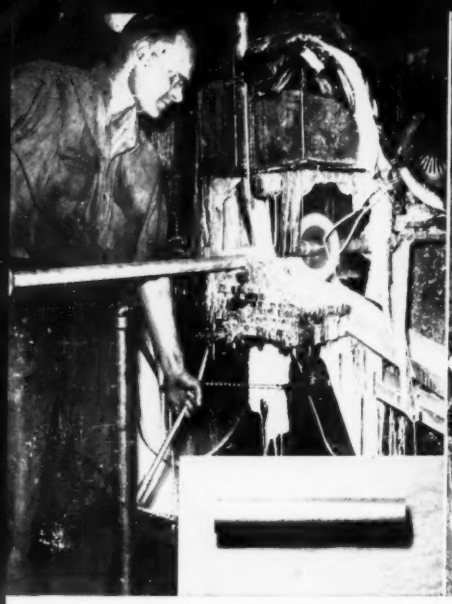
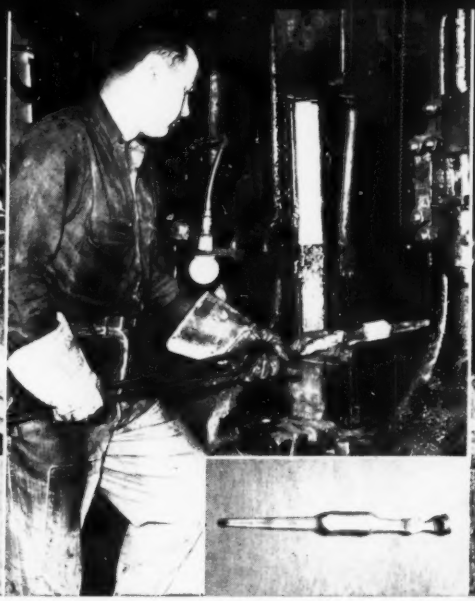
DETROIT

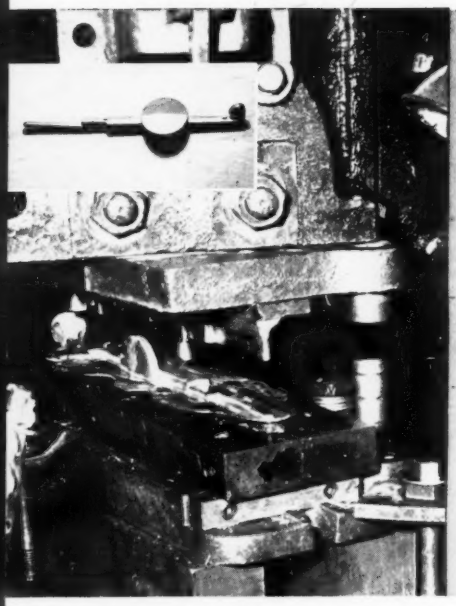


Cutting Bar



Lengthening and Shaping

Shaping to the Die



Trimming the Flash

# FORGING ALUMINUM

## into Pressure Cooker Tops

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# The Harvey Metal Corporation

*HAROLD B. HARVEY '05*

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*FORGINGS IN ALUMINUM — BRASS — BRONZE — COPPER — MAGNESIUM — MONEL — ALLOYS*

*MACHINING FACILITIES*

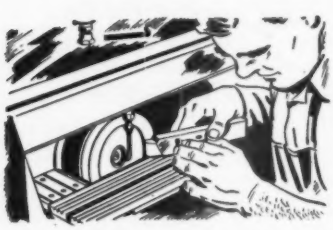
ng

rs

How Allan Pearson might satisfy the curiosity of his 7-year-old son Ronnie. Allan knows the answers. He has worked at Norton for 15 years. In fact, one out of every two Norton employees has more than 10 years' service.

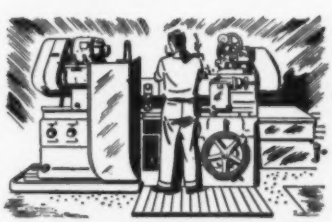
# GEE, DAD, WHAT MAKES IT GO SO FAST?

"It's power that does it, son. Power from its new jet engines. Engines built with parts made from today's strongest, toughest metals . . . parts that fit within one ten-thousandth of an inch."



"Those tough parts are shaped by tougher tools. Tools sharpened by Norton grinding wheels made from our 32 Alundum abrasive, the fastest, coolest cutting abrasive ever made... and our famous Diamond Wheels, a Norton first in 1930.

"Then those engine parts are shaped smooth and true by Norton grinding wheels. And those parts fit each other just right. That's because of the sure finishing touch of Norton grinding wheels and machines.



"And when that giant lands, it lands safely because Norton engineering created a special grinding machine that helps make the landing gears' odd-shaped parts fit true and tight and strong."

"Yes, Ronnie, Norton helps make airplanes better. Other products, too. In fact, there's hardly anything man makes that doesn't get a lift from Norton somewhere along the line. That's why I'm proud of my job of making better products to make other products better."

NORTON

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*Making better products to make other products better*

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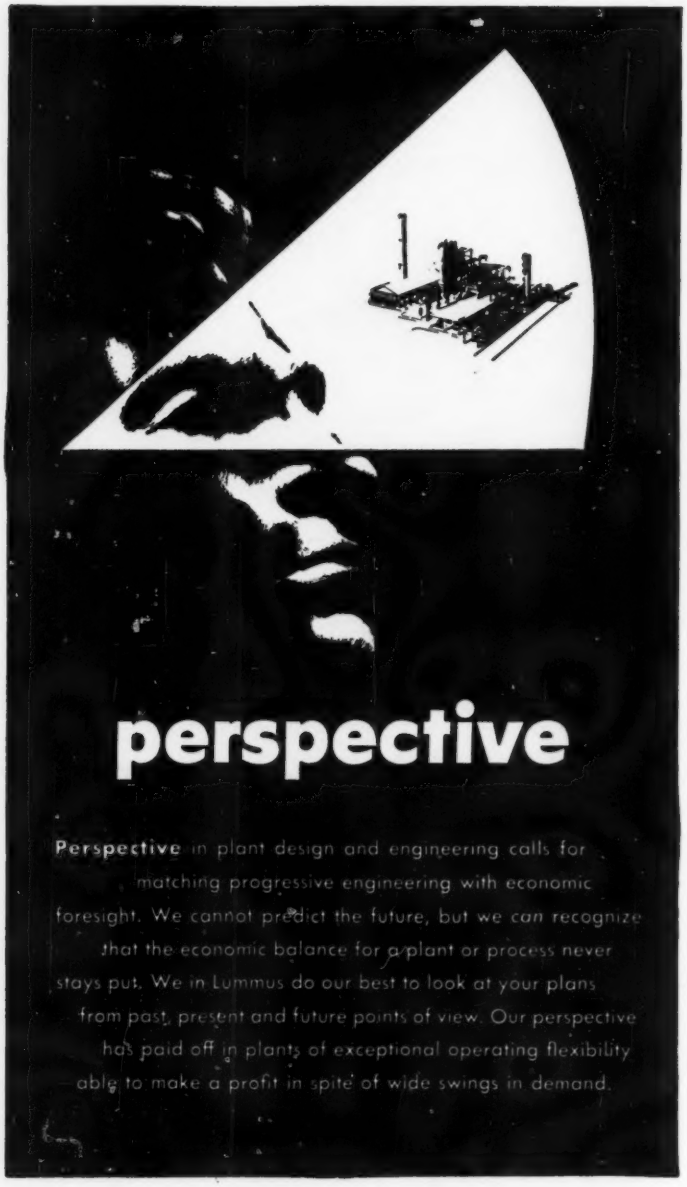

# perspective

**Perspective** in plant design and engineering calls for matching progressive engineering with economic foresight. We cannot predict the future, but we *can* recognize that the economic balance for a plant or process never stays put. We in Lummus do our best to look at your plans from past, present and future points of view. Our perspective has paid off in plants of exceptional operating flexibility able to make a profit in spite of wide swings in demand.

## perspective

In planning this French refinery, both its initial operating level and its ultimate, expanded capacity were guiding factors for design. Room was provided for the easy addition of filters, double pipe chillers and refrigeration equipment, to double the capacity of the unit in this respect. An efficient plant today, it will be equally efficient tomorrow, because expansion need never be "makeshift."

## perspective

Lummus catalytic cracking plants, war-built for 100-octane gasoline, are being operated to produce motor gasoline of lower octane rating on a consistent low-cost basis. Their suitability for this latter service was attained without any compromise in design for their original purpose. Rather, the Lummus-engineered design had the flexibility to meet requirements for the efficient production of either fuel.

## perspective

The interest of Lummus in any of its installations does not end with construction and initial operation for customer acceptance. Periodic visits by Lummus field representatives are continued to review performance. In a recent case where a radical change in product requirements arose, these operating checkups furnished valuable aid in arriving at a prompt and practical plant modification to meet the new demands.

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**teamwork**
**economy**
**fulfillment**
**resourcefulness**
**technique**

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# Westinghouse

## *Another Life-Line First!*

### The Broadest Exchange Plan!

Since February, 1949, Life-Line motors have offered you the broadest exchange plan in industry. All 1 to 20-hp, single-phase and three-phase a-c motors in frame 203 to 326 are included. No other manufacturer of motors—large or small—provides exchange service that compares in scope to this new Life-Line Motor Exchange Service.

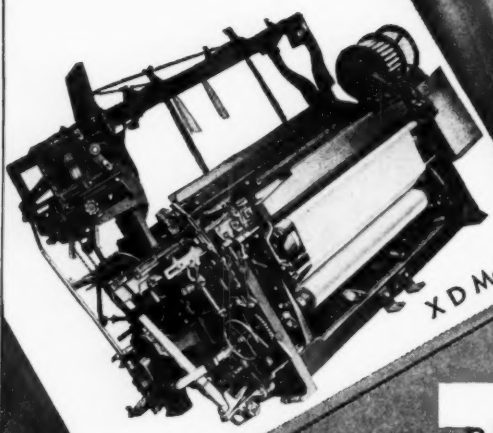
*120 Westinghouse exchange points* assure you rush motor replacement service anywhere in the United States. Replacement motors, covered by this plan, are in stock, ready to be speeded to you at any time.

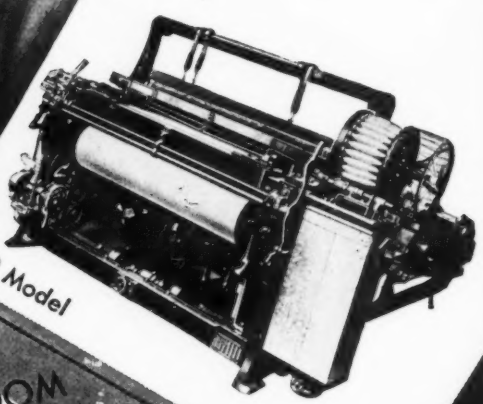
And what's more, if a motor fails during warranty period, it may be exchanged *free* for a motor of identical rating. The *exchange price,* beyond warranty, *is not dependent on the time in service . . . one year, five years or ten years.*

This service is one more advantage you get with Life-Line motors. Add this to all-steel construction . . . pre-lubricated bearings . . . an indicated savings of $750 per year per 100 motors . . . and you'll see why Life-Line has gained leading acceptance in the motor industry.

Complete details on the Life-Line Exchange Service—lists of exchange points and motor ratings covered—are given in the new booklet SM-5243. Get your copy today from your nearby Westinghouse representative or write direct to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Penna. J-21533

**Westinghouse *Life-Line* Motors**

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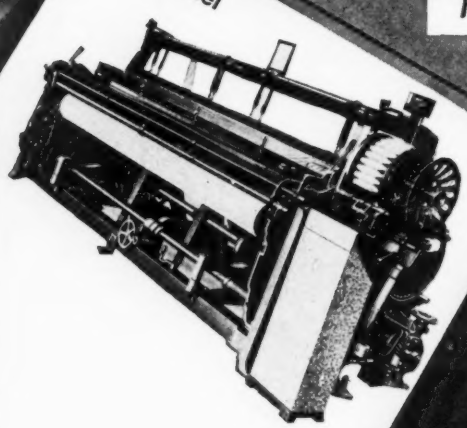
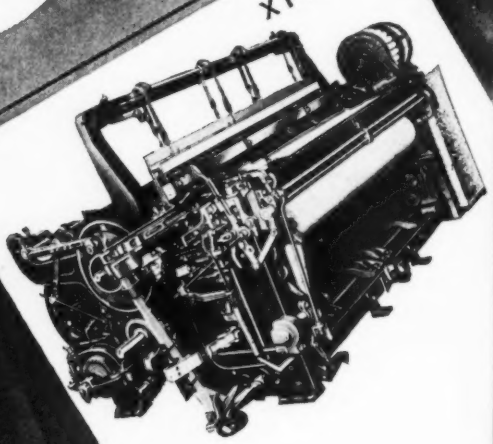
X L Model



X P Model



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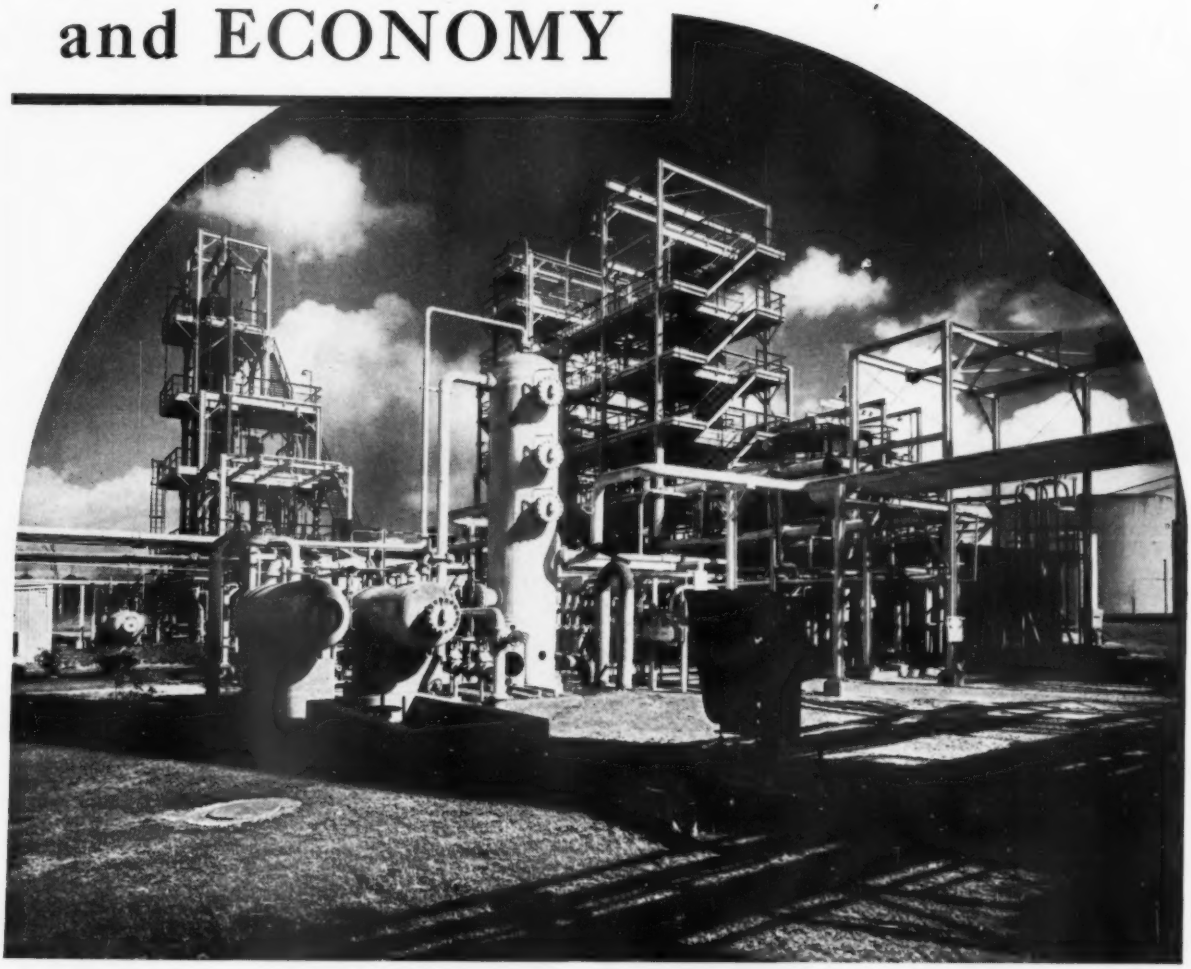

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Place these two new 1950 National Television receivers side by side with any other television receiver. Compare the large (12½") screen — compare the chassis — compare the picture quality — compare the cabinet styling. Because National Television is custom assembled — not mass-produced — there just *is* no comparison! Yet it costs no more.

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Striking modern mahogany table model with 12½" tube and 2 six-inch oval speakers.
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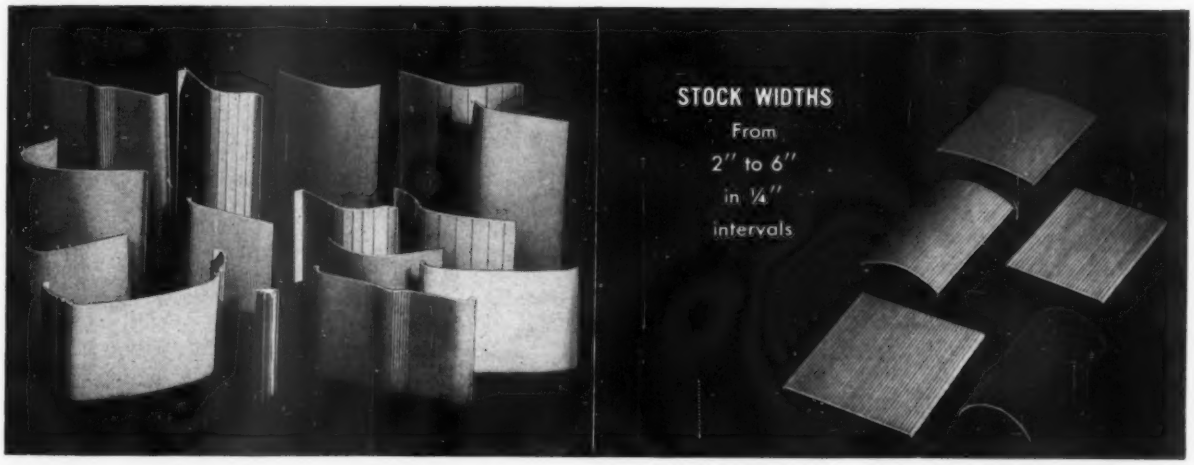


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Custom POLY-LITE side and bottom panels or sections in ever increasing sizes and intricacy of shape are made to close tolerance specifications. Widths up to 15 inches have been produced. We can extrude larger sizes successfully in the newly developed light stabilized material and ship in lengths cut to your requirements.

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Stock POLY-LITE sections of finest quality are now available at surprisingly low cost! Widths from 2 to 6 inches (measured flat) in ¼ inch increments are manufactured without tool charge. They are produced flat or curved to uniform radius in clear or translucent white color.

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Years of extrusion experience, plus our integrity and proven ability are your assurance of top quality, fair price, and successful application of our POLY-LITE panels. Write for additional information on controlled light transmittance, excellent dimensional stability and cost cutting features. Suggestions, ideas, samples, and estimates without cost or obligation.

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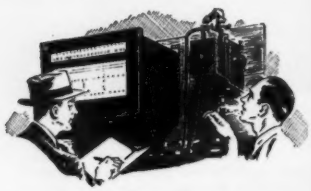
**ITS STAFF** *specializes in giving help on tough measurement problems.*



**TYPICAL SOLUTION** *was development of first "turbidimeter," advancing work on water-purification equipment.*

# 1000 Specialists tell us "When you can measure . . ."

Lord Kelvin, writing in 1883, summed up once and for all the importance of measurement.

"When you can measure what you are speaking about," he said, "and express it in numbers, you know something about it, but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind."

The need for detailed and accurate "numbers" is as great today as it ever was. Recently, for example, General Electric engineers working on water-purification equipment were hindered by the lack of any accurate way to measure water's turbidity. Another group needed data on the vibrations in their equipment.

But at General Electric any group up against tough measurement problems does not have to be stymied for long. It can "appeal" its case, can seek the aid of men who make a specialty of measurement and allied problems—the more than 1000 staff members of the G-E General Engineering and Consulting Laboratory. GE & C serves the entire company, and is also frequently called on by other industries and government agencies.

It solved the two problems above by developing the first "turbidimeter" and a "recording vibrometer" now finding applications throughout industry—two out of thousands of similar problems handled by the laboratory each year.

The work of GE & C illustrates again how General Electric backs up research and creative thinking, implements new projects with the best available facilities, and so remains in the forefront of scientific and engineering development.

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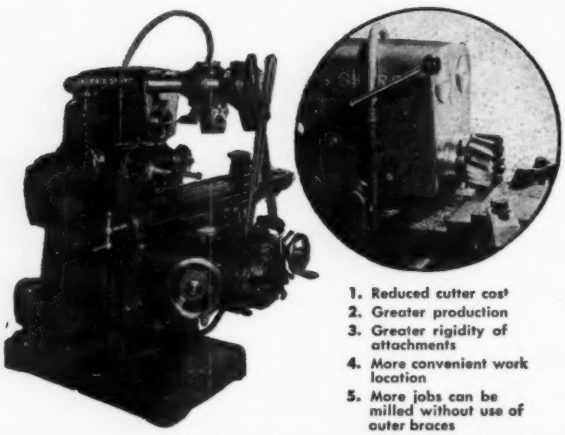

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# THE TABULAR VIEW

**Man of Science.** — Few biographies are more in keeping with the American tradition of the rise to renown from humble beginnings than that of Michael Faraday. His *Experimental Researches in Electricity* mark Faraday as an expositor, par excellence, of scientific prose and as a giant among scientific experimenters of the Nineteenth Century. The rigorous self-discipline to which Faraday submitted, in equipping himself for his life's work, is ably recorded in "Preparation for Discovery" (page 23) by SAMUEL E. MCCRARY. Upon graduation from the Virginia Military Institute in 1930, Mr. McCrary became a student engineer with the General Electric Company, then served four years as first lieutenant in the Cavalry, and another five as installation supervisor with General Electric. He joined the Bureau of Ships, Navy Department, in 1940, and is now research co-ordinator in the Program Planning Branch. In addition, he is secretary of the Senior Engineers' Association of the Bureau of Ships and a member of the City Council and Recreation Commission of Falls Church, Va.

**Intellectual Pursuit.** — For many years after the Institute established courses for advanced study in 1872, the number of graduate students formed a small fraction of the total enrollment. Since the 'Twenties, however, the Institute has graduated an increasing number of advanced students and, at the present time, about one fifth of the entire student body is enrolled in the Graduate School. The present status of the Graduate School, and its progress during the past decennium, are chronicled (page 26) by JOHN W. M. BUNKER, Dean of the Graduate School since the retirement, in 1940, of the late Harry M. Goodwin, '90. Dean Bunker is a graduate of Brown University which awarded him bachelor's, master's, and doctor's degrees in 1909, 1911, and 1912, respectively, and an honorary degree last June. After organizing a new laboratory in sanitary engineering at Harvard University, serving as consultant in biology and bacteriology, and directing the biological division of the Digestive Ferments Company in Detroit, Dean Bunker joined the Department of Biology at M.I.T. in 1921.

**Family Living.** — In the firm belief that the attainment of success, in the usually accepted sense of the term, and the accumulation of money are hardly the ultimate aims in a noble life, anthropologist M. F. ASHLEY MONTAGU urges (page 30) a re-examination and revaluation of the modern way of living. To a major extent, Dr. Montagu limits his observations to the behavior pattern of what is regarded as typical American family life, but his conclusions apply to all human relations. Through his frequent contributions to these pages, Dr. Montagu has been best known to Review readers as associate professor of anatomy at the Hahnemann Medical College and Hospital of Philadelphia. Recently, however, Rutgers University has honored Dr. Montagu by calling him to the chairmanship of its Department of Anthropology.

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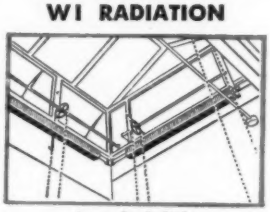
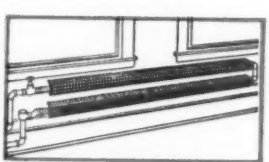
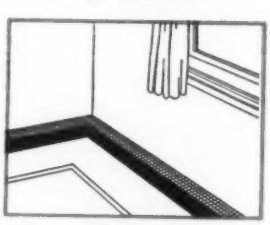


Around skylight



Office Building



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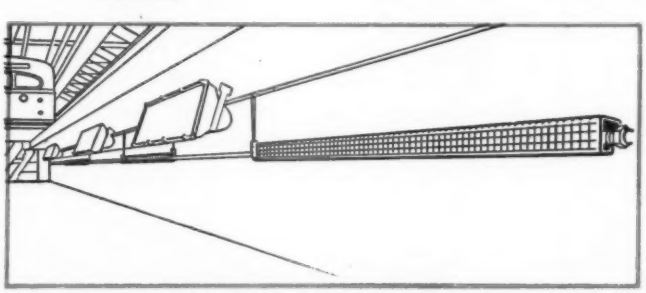

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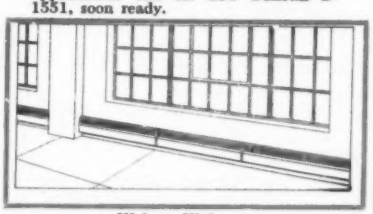

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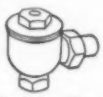

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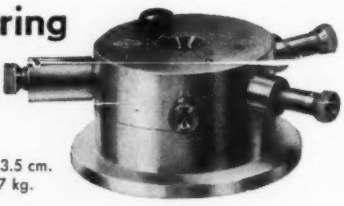

8.3 x 6.5 x 3.5 cm.
Weight 0.17 kg.

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Was first used for photo-electric measurements. Is now used in conjunction with ionization chambers for the determination of radioactive emission. Compact, sturdy, high sensitivity, stable zero and requires no leveling. Capacitance is about 3 cm. Includes improvements developed by the Ryerson Laboratory.

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# MAIL RETURNS

## Boy's View — Centennial, 1876

FROM HENRY HOWARD, '89:

I was much interested in reading Part I of the article entitled "The Centennial of 1876" by E. H. Cameron, '13, in the June, 1949, issue of The Review. I thought my personal recollections of this exposition might be amusing.

I was taken to see it by my father when I was almost eight years old. I remember perfectly the big Corliss engine, also that there was a fascinating little model of this engine in a glass case alongside the big engine. I remember sitting on my father's shoulder so as to look over the heads of the crowd and get a good view of the Brazilian Emperor, Dom Pedro. There was a large and very fine Roosevelt Pipe Organ which furnished music when it was wanted.

I remember very pleasantly the "rolling chairs," at $0.60 an hour, in which my father took me without extra charge, also a captive balloon in which you could make an ascension for a moderate price, and one day in the midst of a thunder squall it broke adrift when it was full of people. This soon became known and caused a great deal of excitement, but the balloon landed safely a few miles away.

I enjoyed every minute of this Centennial and it made a great impression on me.

*Newport, R.I.*

[*Part II of Mr. Cameron's article on the Philadelphia Centennial appeared in the July, 1949, issue of The Review. — Ed.*]

## Therapeutical Agents Abroad

FROM RUDOLF E. GRUBER, '16:

Early this year I made a 14-weeks' tour of Europe, my second postwar visit to that troubled Continent, and I was deeply impressed by the great impact which American help and co-operation has had on recovery. My observations confirm a thought which I have always held that the advance of therapeutics through international co-operation presents perhaps the most civilized aspect of human behavior. The universality of acceptance of new useful therapeutic agents, such as penicillin and streptomycin, and others confirms this point of view.

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**In whatever connection, scientists who may want more information on Krypton, Xenon, Argon, etc., are invited to write us fully. Please write Dept. LAP, Room 1502, 30 East 42nd St., New York 17, N. Y.**

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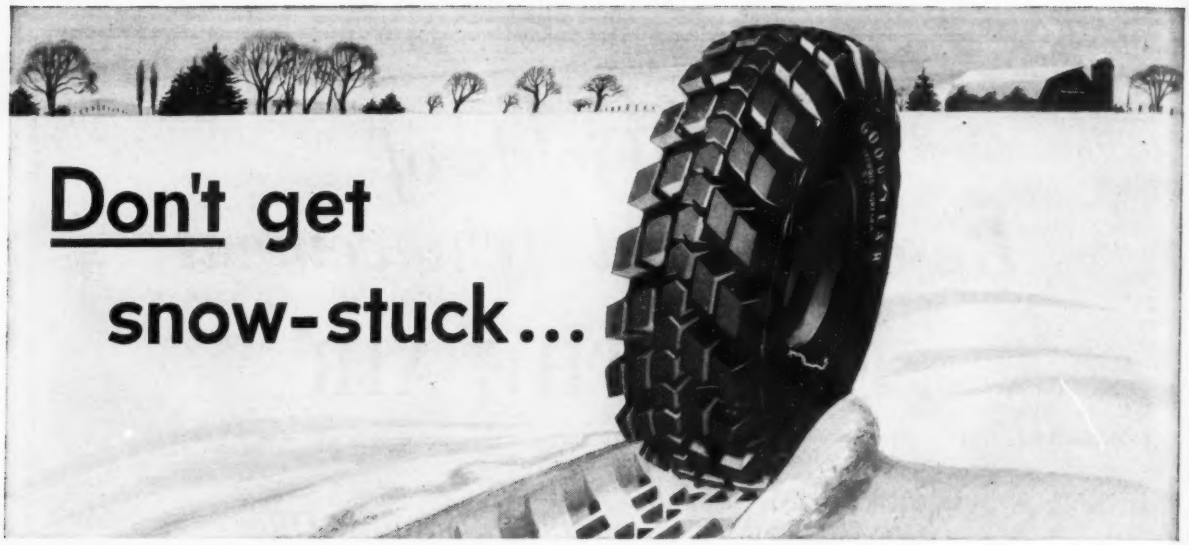


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*EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY*

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J. Stojan

*Ribbons over Roof Tops*

THE
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REVIEW

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# The Trend of Affairs

## *Graphic Arts Research*

RARELY does one find an important industrial operation in which technical progress remains at the same level for more than half a century. Yet this situation does exist in the field of type composition. The last major change in typesetting – the transition from hand set to machine composition – occurred more than half a century ago; for both Linotype and Monotype machines were invented and in use before 1900.

Some have said that movable type is man's greatest invention, but this does not deny the fact that an exceedingly cumbersome arrangement is used for putting ink on paper in the desired pattern. The possibility of newer and more promising ways of setting type and making ink impressions has been opened up by research in the field of the graphic arts. It is small wonder, therefore, that leaders in this field feel that present methods of printing will soon be obsolete and that, under increasing economic pressure, far-reaching changes must be made as quickly as possible. Such changes are expected to come about in two parts – in typesetting and in making impressions – and already significant progress has been made in a revolutionary method of type composition.

Of the many attempts which have been made to improve methods of composition, the most promising have been based on the idea of composing the printed page on photographic film instead of in the form of metallic type. The great promise of photographic composition lies in its flexibility and economy. Freed from the necessity of cutting and shaping metal, characters can be projected onto film in a bewildering variety of styles, sizes, and groupings. At the same time, costs are sharply reduced not only by the increased speed of composition, but also by the elimination of tons of heavy type metal inventory.

A new photocomposing machine which has recently been operated in public demonstrations makes use of a number of modern technical developments in achieving its success. An electric typewriter not only records the material being composed but also provides enough energy to operate auxiliary equipment attached to it. Relays and switches which were developed to meet the needs of automatic telephone systems are used in the new machine to provide reliable control and to carry out at high speeds the computations required in justifying lines. Photoelectrically actuated electronic equipment controls the high-intensity flash lamp which places each character on the film with the precision required in modern printing.

A block diagram (page 18) is useful in understanding the photocomposition process. The material to be composed is typed on an ordinary typewriter keyboard and the operator can see immediately whether any corrections are necessary. Associated with each character is a binary number code which identifies that character uniquely. When a key of the typewriter is pressed, the code corresponding to the character on that key is stored in a special register associated with the typewriter. When the end of the line is reached, all of the characters and spaces contained in that line are held in coded form in the storage unit. This makes it possible to complete the justifying operation and compose the line without retyping it.

As soon as the operator completes a line and finds it satisfactory, it is released for composition. The operator can then begin to type the next line. At the same time, a reading carriage begins to move along the storage unit, and it transmits to a decoder and control unit the identification of the characters which are in storage. The decoder identifies the character called for and controls the photographic projector so that the correct character is selected and projected on the photographic film. It also determines the width of the



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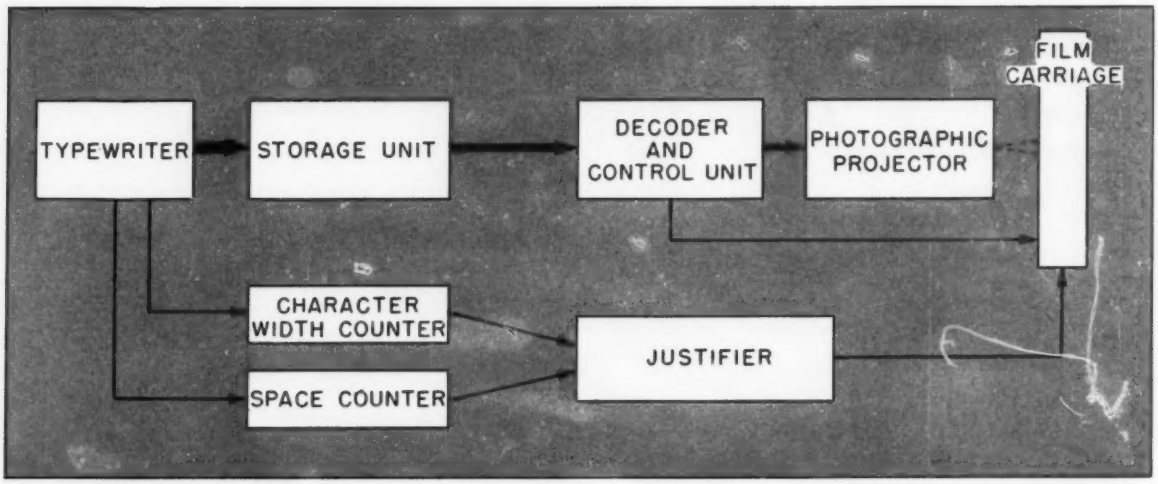


*Block diagram illustrating the functional elements in a new method of photographic type composition. Main features of an experimental machine recently publicly demonstrated include: (1) use of ordinary standard typewriter keyboard; (2) dial and push button controls to change font, type size, typeset, and justification; (3) copy immediately visible to operator for proofreading; (4) corrections made by use of keyboard controls in a manner similar to ordinary typewriting; (5) large range of justification of lines under fully automatic control. At present photocomposition can be performed at a rate of six characters per second, although this speed can be increased. The end product can be either a positive or a negative transparency ready for use in any photomechanical process.*

character and, after it is projected on the film, moves the film carriage an amount corresponding to the width of the character exposed.

Information concerning the width of each character is contained within the same code that identifies the character itself. By using several of the digits of the binary code which identifies the character, it is possible to make a double-purpose code which both identifies the character and tells its width. These width digits are sensed separately by the decoder and control unit in order to move the film carriage an appropriate distance after each character is exposed.

At the time the character is originally selected on the typewriter keyboard, the width digits are sensed by a separate set of contacts and transmitted to the character width counter. This device simply adds up all of the separate widths of the characters typed, together with the nominal widths of the spaces between words. An electrical circuit determines the difference between the available space in a line and the accumulated width of characters typed, and presents this difference on a meter to the operator, so that typing will stop before the line is full. A separate counter, called the space counter, adds up the number of spaces between words. If the amount of space left over at the end of the line is divided by the number of spaces between words, and this quotient is added to each of the interword spaces, the line length will equal its predetermined value and it is said to be justified. This operation is performed by the justifier unit shown in the block diagram. It will be noted that this unit controls the spacing of the film carriage. Each time there is a space between words, the film carriage is moved ahead an amount equal to the nominal width of a space, plus the additional width put in by the justifier to make all the lines come out at equal length. In actual operation, the justifying increment added to the interword spaces is not always exactly alike for each interword, but the amount of variation is too small to be observed.

All of the characters and symbols needed for composition are carried as either positive or negative photographic images on a drum or disc which rotates at high speed. By using intense light flashes of short duration, it is possible to select any character and project it on the film with sharp definition. Type style can be changed by selecting a different band on the drum or by using a different disc. The size of type may be varied over a wide range by changing the optical magnification of the system. At present, the speed of the rotating matrix permits composition of six characters per second, and this can be increased to 10 characters per second quite readily.

One important feature of the machine is the flexibility of control which the operator has available at the keyboard. Size and style of type are chosen by selector switches, while another selector enables the operator to determine the length to which each line is to be justified. Errors are detected by reading the typed material. If serious errors occur, the operator can "kill" the entire line and retype it. To correct a faulty character, it is merely necessary to position the typewriter platen at the location of the error, press a correction button, and strike the correct character over the incorrect one.

This machine was invented by two French engineers, René A. Higonnet and Louis M. Moyroud. A number of M.I.T. men have been concerned with the development since it was first brought to this country. William W. Garth, Jr., '36, as President of the Lithomat Corporation, was instrumental in providing support for the development of the invention to the present demonstration model. During that period, Professor Samuel H. Caldwell, '25, of the Department of Electrical Engineering at M.I.T., acted as a consultant for the Lithomat Corporation Professor Harold E.

Boston Herald

This is to show the extent of the justification range
This is to show the extent of the justification range

This is to show how the length of lines can be varied at will.
This is to show how the length of lines can be varied at will.
This is to show how the length of lines can be varied at will.
This is to show how the length of lines can be varied at will.
This is to show how the length of lines can be varied at will.

The cylinder is placed at one end of the bed-plate, and the crank-shaft at the other end, and through the piston rod a connecting rod, and the crank on the shaft, the rectilinear reciprocating motion of the piston is converted into a continuous rotary motion. In order to compel the end of the piston-rod attached to the connecting rod at the cross-head to move along a straight line, the slide-blocks fixed on both sides of the cross-head are made to slide between guides cast in one piece with the bed plate.

Above: *A few examples of photocomposition produced on the experimental machine and selected to show some of the possibilities of the new process. The type face does not represent the work of professional type designers.*

Left: *Dr. Bush and Professor Caldwell operate the electric typewriter during public demonstration of an experimental model of photocomposing equipment.*

Edgerton, '27, also of the Electrical Engineering Department, has been assisting in the design of the stroboscopic light system used.

The intense interest aroused by this development among leaders in the printing and publishing business has led to the organization of the Graphic Arts Research Foundation, Inc. The Lithomat Corporation has turned over to the new Foundation, which is organized on a nonprofit basis, all of its patent rights in the new development. Support for the further development of the photocomposing machine to commercial form is derived from the contributions of about 140 firms in the newspaper, book publishing, manufacturing, lithographing, and commercial printing business.

An outstanding supporter of the new Foundation is Vannevar Bush, '16, President, Carnegie Institution of Washington, who is one of the life members of the Foundation. Dr. Bush is turning over to the Foundation his patents and other work in the field of graphic arts where, by his contributions, he once again demonstrates his striking versatility. In addition to Dr. Bush, Mr. Garth and Professor Caldwell are also members and directors of the Foundation.

## *Pincus No. II*

THOSE who follow Al Capp's comic strip need not be reminded of L'il Abner's harrowing experiences with a denizen of the planet Pincus No. II. The immaculate condition in which our interplanetary traveler, *B–69–O*, arrived on earth illustrates one of the outstanding advantages of the artist over the engineer. Mr. Capp portrayed *B–69–O* in neatly pressed attire such as Superman might expect to find displayed in the pages of *Esquire*, and dropped the matter there. But in the *Journal of Applied Physics* for October, 1948, George Grimminger, '38, indicates that a real space traveler, or at least his ship, may be subject to considerable wear and tear. Space, it seems, is not nearly the frictionless void it has been pictured.

Assembling the known data on the prevalence of meteorites in the earth's vicinity, and the equally sketchy information on the penetrability of metals by extremely high-speed masses, Mr. Grimminger calculates the probability of an encounter between a space ship and a meteorite, and even estimates the thickness of metal plate required to prevent perforation by the impact of meteorites of different sizes. The number of meteorites large enough to survive their blazing dash through the atmosphere is so small that a collision between such a body and a ship still in the vicinity of the earth may be discounted. Only five or six meteors reach the earth's surface every 24 hours, it is believed. As the meteorites get smaller, however, with weights that are measured in grains rather than in pounds, their numbers increase greatly. Stone and iron particles of dust size, perhaps 0.002 inch in diameter or larger, strike the earth's atmosphere by the hundreds of billions per day. Nor can meteorites of these tiny sizes be dismissed as harmless, for upon entering the earth's outer atmosphere their velocities may reach 250,000 feet per second.

Against a thin aluminum skin cosmic particles of even such small size could be damaging, particularly if they were composed mainly of iron and nickel, as about one-tenth of all meteorites appear to be. A heavier stainless steel skin might be immune to meteorites up to 0.02 inch in diameter, of which size the earth may sweep up hundreds of millions per day. Although these numbers are enormous, the volume through which they are scattered is so immense that preliminary calculations indicate no major danger of a damaging collision between any reasonably sized space ship and a meteorite.

A ship, if that is the word, having an exposed area of 1,000 square feet and a stainless steel skin nearly one-sixteenth inch thick could expect to remain in re-

gions near the earth for more than 100 hours before the chances of being holed reached one in 1,000. If the skipper were willing to accept a 50–50 chance of escaping damage, he could remain aloft for a period of about 10 years.

During such intervals, however, the ship would be hit many times by particles too small to penetrate but with sufficient momentum to dent and abrade the hull. One would expect, therefore, that our space passengers would encounter not the ultimate quiet of a clean-swept void but rather a series of rustlings and clangs as they brushed through the debris of the cosmos.

## *The Trend in Rockets Is Up*

EVER since the first ex-German V–2 took off from the White Sands Proving Ground in New Mexico, rocket experts looking at the one-ton war head carried by these rockets have talked about the results which could be achieved if that one-ton war head were replaced by a one-ton rocket. After a preparation of one year this experiment was made on February 24, 1949, when a *V–2* rocket took off at White Sands, carrying an American-made *WAC Corporal* as an "upper step." The *WAC Corporal,* taking over after the *V–2's* fuel supply was exhausted, reached a maximum velocity of one and thirty-nine hundredths miles per second, and a peak altitude of 250 miles. This more than doubled the previous altitude record for rockets which was made by a *V–2* traveling alone to 116 miles on December 17, 1946.

In the two-stage experiment, the body of the *V–2* crashed about 20 miles to the north of the firing platform, while the *WAC Corporal* was tracked by radar to an impact point between 80 and 90 miles north of the firing platform. So far, however, the actual impact point has not been found and people who know this area best are very doubtful that it ever will be found, except perhaps by accident.

While step rockets have been built earlier, all step rockets so far have been powered by solid fuel. This is the first experiment of this kind involving liquid fuels. The *WAC Corporal,* the result of collaboration between the California Institute of Technology and the Douglas Aircraft Company, made its debut also at White Sands, by coincidence on the same date, February 24, 1946. The first firing of the *WAC Corporal* was undertaken with a solid fuel booster which raised the take-off weight of the whole to 1,000 pounds. The rocket reached an altitude of 230,000 feet.

Although the two rockets, which operated as lower and upper steps of the same aggregate, are both liquid-fuel rockets they differ in very many particulars, even if the vast difference in size be disregarded. The 46-foot tall *V–2* has a streamlined hull, the *WAC Corporal* is cylindrical, with a conical nose. It stands 16 feet high and the cylindrical body measures one foot in diameter. In the *V–2* rocket the fuels are forced into the rocket motor by centrifugal pumps. In the smaller *WAC Corporal* such a device is not needed as fuel feed is accomplished by means of gas pressure. In the *V–2* the fuel is 150-proof grain alcohol with liquid oxygen. In the *WAC Corporal* the fuel is aniline, and the oxidizer is red fuming nitric acid. This combination has the advantage that ignition is instantaneously automatic; all that has to be done is to bring the two liquids together.

The take-off weight of the *WAC Corporal,* without booster (as it was probably used in this experiment), is 665 pounds: the fuel load weighs 385 pounds. The thrust of the motor at sea level is 1,500 pounds so that the thrust of the *WAC Corporal,* when it took over in this experiment, must have been close to 1,700 pounds, producing an acceleration of more than 48 feet per second per second, which is somewhat higher than the take-off acceleration of a *V–2*. Maximum acceleration of the *WAC Corporal* must have been about five times the acceleration due to gravitational attraction. Its fuel supply lasts for 38 seconds of burning.

The main significance of this experiment is that the somewhat ticklish problem of igniting the upper step, and of lifting it out of the lower step, has been solved successfully. That the solution of this problem would lead to the establishment of a new altitude record was obvious, since the altitude reached by a rocket depends on its maximum velocity and since the velocities of the two steps add up.

All in all, it can be said that liquid-fuel rockets live up beautifully to the theory which was evolved over 20 years ago. The trend in rockets is still up, and the day when the upper step of such a combination will fail to return, because it has been established in space in an orbit around the earth, is coming steadily closer.

## *Stripes of Color*

CHROMATOGRAPHY, a method of chemical analysis that was discovered in 1906 but then lay fallow until the 1930's, has recently burgeoned into widespread use for separating and purifying chemicals from mixtures inseparable by other means. Chromatography is that rarity among scientific advances, the product of a flash of genius on the part of a single inventor. Michael Tswett, who discovered this procedure early in the current century, called his method "chromatography" because he used it to separate colored materials found in plants. The name adheres despite the fact that the method now is used as much or more for the resolution of colorless mixtures.

Although chromatography is a method of chemical analysis, it depends, paradoxically, upon a physical principle – adsorption. Adsorption is surface adhesion, in extremely thin layers, between gases, solutes or liquids, and solid particles. The classic procedure established by Tswett, and still used in certain applications, serves nicely to demonstrate how differential adsorption acts to resolve mixtures. Tswett packed a vertical open-ended glass tube with powdered chalk, and then allowed a mixed solution to percolate downward through this column. He found that certain substances were trapped in the column by adsorption on the chalk, thus being removed from solution and allowing pure solvent to escape at the bottom of the tube. He also discovered that different substances were caught at different levels of the tube; the more strongly adsorbed compounds were held near the top of the column, whereas those less strongly adsorbed

were held further down. By "developing" the column through flowing pure solvent through the chalk, he found that each member of the mixture could be consolidated into a sharply defined, separate band or stripe.

Once a chromatogram has been established and developed, the several substances adsorbed on the column may be obtained individually and in pure form by one of the various procedures. A direct approach is to extrude the contents of the packed column in one piece, separate the various bands by cutting them apart with a knife, and then free each compound separately from the section of the adsorbent holding it by dissolving in a suitable solvent. But components of a chromatogram may also be obtained separately without disturbing the column. One procedure is to flush the chromatogram continuously with the solvent used to establish it; thereupon the separate bands migrate downward, and pass out of the bottom of the tube one at a time. Or by changing to a different solvent, it is sometimes possible to wash one band out of the column without releasing the others.

In Tswett's original experiments, the bands of the chromatogram were readily localized visually because of their colors. When colorless substances are separated by chromatography, the limits of each zone are gauged by odor, by chemical tests, by biological tests in the instance of materials like antibiotics, by use of x-ray and electron diffraction analysis, or by means of a Geiger-Müller counter if radioactive isotopes are concerned.

Other substances besides chalk used in adsorption columns include silica, alumina, carbon, various clays, cellulose, cotton, and starch. A wide variety of solvents, either in pure form or as mixtures, may be used; among these are water, phenol, petroleum ether, benzene, butyl alcohol, methanol, and ethylene dichloride. Since adsorption of a compound in chromatography depends not only upon the compound itself, but also upon the adsorbent used as well as the solvent or mixture of solvents employed, the potential effectiveness of chromatography in separating mixtures is virtually boundless. To date, behavior of materials in chromatography has been observed mainly on an empirical basis, although relationships between such behavior and molecular structure are being studied and some have been established.

Only a single revolutionary latter-day advance in chromatography – the paper chromatogram – has been made since Tswett's basic discovery. This procedure uses a sheet of filter paper as the adsorption column. Solutions and solvents are flowed through a vertical sheet of paper either by allowing the liquid to pass upward through capillary action, or else by bending the upper margin of a sheet over the edge of a trough, into the fluid contained in the trough, and thus enlisting gravity to aid the flow. One immediate advantage of the paper chromatogram is ease of use; for proper packing of powder into a tube to make the conventional column is difficult and tedious. Furthermore, extrusion of the column in the event that it is desired to dissect it requires much skill, whereas paper chromatograms are readily cut apart with scissors. But the outstanding superiority of paper chromatography lies in the fact that it makes possible two-dimensional chromatograms. In this procedure, an unknown is placed on the upper left-hand corner of a sheet of paper, and a chromatogram is established down the left-hand margin of the sheet by a flow of one particular solvent in this direction. Next, the sheet is rotated through 90 degrees, so that the initial chromatogram now appears across the top margin of the paper. Then development is resumed with a different solvent flowing vertically, thus at right angles to the original direction of flow. In this way the chromatogram is developed still further, until the components of the origi-

*The Mid-Century Convocation held at M.I.T. last spring provided opportunity for* (left to right) *Alfred L. Loomis, Sir Henry Tizard, and Lee A. DuBridge to examine the pulsed magnetron, a key development of World War II radar. Sir Henry, formerly president of Magdalen College, Oxford, headed the British scientific mission which brought the magnetron to America, and Dr. Loomis, chairman of the Microwave Committee of the National Defense Research Committee, figured importantly in establishing M.I.T.'s Radiation Laboratory when it undertook the practical applications of this discovery. Dr. DuBridge was director of the Laboratory during World War II, and is now president of the California Institute of Technology in Pasadena.*

*M.I.T. Photo*

nal mixture are distributed as isolated spots over the full area of the paper (hence, two dimensional). The extraordinary sensitivity of two-dimensional paper chromatography is illustrated by the fact that it has been used to segregate 22 different amino acids, compounds so closely related that they are difficult to separate by any other means, from a sample weighing less than one two-thousandth of a gram.

In the Eighteenth Century, crystallization was the principal means available for separation of chemicals and their preparation in pure form. By the middle of the Nineteenth Century, distillation had been so perfected that it could be applied intensively in the separation of volatile compounds that do not crystallize readily. At present, chromatography has assumed the leading role in the resolution of mixtures that crystallization and distillation occupied in their day. Chromatography now is used to separate mixtures of virtually every type of substance, including inorganic compounds, fatty acids, amino acids, carbohydrates, antibiotics, enzymes, and vitamins. It has proven effective in the isolation of substances ranging from hydrogen ions with a molecular weight of unity, to the largest proteins and colloidal particles with molecular weights in the order of a million.

## *Palatable Prospect?*

A CHEMICALLY transformed world of tomorrow, which could support a population of 15 billion living in earthenware houses and eating butter from coal, sugar from trees, and proteins from yeast, was envisioned by a Harvard University chemist at an American Chemical Society meeting in Newark, N. J., at which he received a gold medal and $1,000 cash for helping to build a new industry out of sand. The speaker was Eugene G. Rochow, and the world he pictured would be made possible largely by the use of inexhaustible instead of exhaustible raw materials. Houses, for example, would be built of excavated earth fused into bricks and slabs on the spot. Meat and eggs would disappear from man's diet because the animals producing them consume too much food. Cellulose from trees, a highly efficient type of plant, would be converted into edible sugars; synthetic clothes as well would be made from it.

Petroleum provides a striking example of the plight in which the human race is rapidly involving itself. With an estimated 58 per cent of the original petroleum reserves of the United States gone, current efforts to avert a fuel crisis are centered in the synthesis of gasoline and oil from natural gas and coal. But these raw materials, in turn, can be exhausted, and, besides, there is competition for the coal reserve on the part of the coal industry, the chemical industry, the metallurgical industries, and the electric power industries, in addition to the petroleum industry. Some day coal may be needed for food and so denied to all other industries.

Probably man's present eating habits will have to be radically altered before many generations pass. It took nearly five acres of arable land per person to feed the United States in 1947, and on this basis, even if every bit of land in the country, except deserts, swamps, and rocky areas, were cultivated, only some 306,000,000 people could be supported. Moreover, forest lands could not be expected to yield as much as our present farms, and soil erosion would be greatly increased by cutting down all trees.

It would be better, in Professor Rochow's view, to continue growing trees and to use them for food. Although man cannot digest cellulose from trees directly, the cellulose could be converted into digestible sugars that would supply all carbohydrate needs. Meat and eggs as sources of proteins seem certain to vanish from the human diet, for a beef steer converts only about 12 per cent of its food to meat, and does worse at it when poorly fed.

Ultimately, Professor Rochow explained, the real problem will be to assure a continuing supply of atmospheric carbon dioxide from which plants can build their tissue. Carbon dioxide is steadily being soaked up by the oceans, and it will have to be recovered from them. If this problem, and the others connected with nutrition, are solved along the lines indicated, he said, "a United States population of about one billion people and world population of 15 billions would not seem unreasonable."

## *Rugged Electron Tubes*

FOR about 30 years after Lee DeForest invented the three-element electron tube, tubes of all kinds were regarded as fragile bits of wire and glass. The introduction of the metal-cased radio tubes about 1936 did much to change thinking regarding the fragility of these devices, but it was not until World War II that any large-scale serious efforts were made to develop designs and manufacturing techniques to make tubes as rugged as any piece of mechanical equipment subjected to rough usage, for the need for rugged tubes was emphasized by their use in proximity fuses.

The ordinary user of radio tubes has benefited from the wartime program of "ruggedization," and so has the industrial user, for rugged electron tubes are indispensable wherever electronic equipment is used under severe conditions of vibration, shock, or acceleration. Important in the development of such tubes are methods of testing for sturdiness and durability. These methods are now being studied and developed at the National Bureau of Standards, as well as in the laboratories of commercial types of tubes, as part of a comprehensive tube-ruggedization program. One phase of the project consists of a survey of the actual operating conditions for electron tubes in various kinds of commercial, industrial, and military applications. This study provides a practical basis for the design of test equipment to simulate the hazards of actual use.

In addition to working out adequate test methods, the Bureau is developing new kinds of rugged tubes. The design of these tubes is based on an analysis of the ways in which ordinary tubes fail under test or in service. A detailed knowledge of operating conditions and tube failures is thus a useful guide to the design of tubes that will be strong enough to operate properly under severe mechanical abuse. Some tubes may have

(*Continued on page 50*)

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*Probably the foremost experimentalist of Nineteenth-Century investigators, Michael Faraday is shown in his laboratory where the foundations were laid for his* Experimental Researches in Electricity.

# Preparation for Discovery

***Self-Education through Determination and Perseverance Led Michael Faraday to Renown as Outstanding Nineteenth-Century Research Worker***

**By SAMUEL E. McCRARY**

The name of Michael Faraday seems to be surrounded by an aura of wonder, almost reverence, whenever it is sounded among men of science. Biographies, memorials, and awards show that this has been true for more than 100 years, including quite a few years of his own lifetime. As years pass, and in our hurried search for newer things we find little opportunity to look back and critically examine the basis for his greatness, we take it for granted. Our textbooks of science tell us of his wonderful discoveries about natural things, but very little about the precepts which guided him; the methods and attitudes which he applied rigorously to uncover nature's secrets.

Sir Humphry Davy, at the height of his fame, was once asked what he regarded as his own most important discovery and he replied, "Michael Faraday." Had he then been asked what he regarded as Faraday's most important discovery, he might have answered again, "Michael Faraday," for self-discovery was perhaps the most important factor in Faraday's remarkable success.

Michael was born in London on September 22, 1791, to Margaret Hastwell, a farmer's daughter, and James Faraday, a blacksmith. There were then two older children, Robert, aged three, and Elizabeth, aged four. Eleven years later there came another sister named Margaret. From all accounts this little family lived an uneventful existence – simple, honest, religious, and hard-working. They were poor, too, for it has been recorded that the family was for a time on public relief. The children went to common day school and played marbles and other games in the streets.

Nearby at Number 2 Blandford Street was the bookshop of George Riebau who employed Michael at the age of 13 as an errand boy, on trial for a year. His first duty was delivering newspapers, and his customers, exacting in their demands, gave him cause to say in later years: "I always feel a tenderness for those boys because I once carried newspapers myself."

At the age of 14, Michael was indentured as an apprentice bookbinder to Mr. Riebau for seven years at no pay. It was here, under a kindly master, that he

began work on his preparation for discovery. He wrote as follows:

Whilst an apprentice, I loved to read the scientific books which were under my hands, and, amongst them, delighted in Marcet's "Conversations in Chemistry," and the electrical treatises in the "Encyclopaedia Britannica." I made such simple experiments in chemistry as could be defrayed in their expense by a few pence per week, and also constructed an electrical machine.

His master allowed him to hear evening lectures on natural philosophy by Mr. Tatum at his house in Fleet Street. These lectures cost a shilling each, advanced by his older brother, Robert, a blacksmith. Through Mr. Tatum he made friends with Benjamin Abbott, a confidential clerk, and a Mr. Magrath. Also, a Mr. Dance, a member of the Royal Institution, who arranged for him to hear four lectures by Sir Humphry Davy in the spring of 1812. Of these he took careful notes and used them to considerable advantage a short time later.

About the same time he began a correspondence with Benjamin Abbott in which they exchanged frequent letters to improve their ability to write. They continued this correspondence for many years, even though they saw each other frequently. Each letter usually contained a short essay, or a description of some experiment in natural science which they had conducted.

After completing his apprenticeship, he went as a journeyman bookbinder to a Mr. De la Roche, but his thirst for natural science left him with little taste for his trade. With some boldness he wrote a letter to Sir Humphry Davy telling him of his desire to "enter the service of science," and as proof of his earnestness sent bound copies of the notes he had taken of Davy's lectures. Sir Humphry was so pleased by this sincere compliment that he sent for Faraday and engaged him on March 1, 1813, as an assistant in the laboratory of the Royal Institution, at 25 shillings a week, with two rooms at the top of the house.

A few weeks afterward, Mr. Magrath introduced him as a member of the City Philosophical Society which had been founded by Mr. Tatum. Of this Faraday wrote:

It consisted of thirty or forty individuals, perhaps all in the humble or moderate rank of life. Those persons met every Wednesday evening for mutual instruction . . . and considered and discussed such questions as were brought forward by each in turn. . . . We had a "class book" in which, in rotation, we wrote essays and passed it to each other's houses.

He described still another means of self-education:

During this spring Magrath and I established the mutual-improvement plan, and met at my rooms up in the attics of the Royal Institution, or at Wood Street at his warehouse. It consisted perhaps of half-a-dozen persons, chiefly from the City Philosophical Society, who met of an evening to read together, and to criticise, correct, and improve each other's pronunciation and construction of language. The discipline was very sturdy, and the remarks very plain and open, and the results most valuable.

So, by reading, listening, observing, and testing himself through writing and lecturing, he developed his powers of analysis and expression. Apparently his preparation by these means was so thorough that Davy was highly impressed, for he asked Faraday to accompany him on an extended tour of the Continent to serve as his assistant and amanuensis.

On October 13, 1813, Sir Humphry, Faraday, and Lady Davy left England to visit the great men of science in Europe and to explore their laboratories. Davy was then one of the most renowned of scientists and his reputation was such that he was granted safe conduct through all the countries even though wars were imminent or actually in progress. This grand tour, lasting for a year and a half, provided direct contact with the fountainheads of contemporary and historical scientific knowledge. Faraday wasted none of it. He carefully kept a diary, and of course, notes on such experiments as were made by Davy and his colleagues. He met Ampère, Clément-Desormes. He and Davy examined a strange new substance, iodine, discovered by Courtois, and later shown to be an element by Gay-Lussac. He had a glimpse of Napoleon, who was then waging war on England. They talked with Arago, Gay-Lussac, Chevreul, Volta, de la Rive, and many others. Lasting friendships were made with some of them. They crossed the Alps and climbed Vesuvius twice. In Florence, Faraday saw Galileo's first telescope, and with the great lens of the Duke of Tuscany they burned a diamond at the Accademia del Cimento. He observed the peoples at work and at play, and learned something of their languages.

They returned to London in 1815. Davy went to his experiments in the laboratory of the Royal Institution with Faraday as his assistant. He watched Davy's studies of gases and flame which resulted in the invention of the safety lamp. All the while Faraday studied his master, praised his successes openly, and privately judged his faults. Gradually, Davy set Faraday to work on his own. He developed great skill in handling laboratory apparatus for experiments but he was never satisfied with an experiment until he had repeated it before an audience.

In this stern way he continually tested himself for errors in judgment as well as in expression. An insight into the seriousness with which he regarded self-examination may be gained from his remarks in a lecture on "Inertia of the Mind" in 1817, when he was 26 years of age:

Industry is the natural state of man, and perfection of his nature is dependent on it; the progression which distinguishes him from everything else in the material world is maintained by it alone. The sun rises and sets, and rises and sets again. Spring, summer, autumn, and winter succeed each other only to be succeeded by the same round. A plant rises from out of the earth, puts forth leaves and buds; it strengthens, arrives at maturity, and then dies, giving place to other individuals who traverse the same changes. An animal is born, grows up, and at last gives signs even of intelligence; but he dies without having improved his species; and it is *man alone* who leaves a memento behind him by his deeds of his having existed; who surpasses his predecessors, exalts his present generation, and supports those that follow him . . . If he be not active, not in a state of improvement, what better is he than the brutes?

With all his intensive self-examination and study he was not so much of an introvert that he could not

enjoy the society of others in simple pleasures of life. This is indicated from his diary. Typical is an entry about a walking tour in Wales, dated July 19, 1819:

Proceeding onwards into Brecknockshire, we suddenly heard the roar of water where we least expected it, and came on the edge of a deep and woody dell. Entering among the trees, we scrambled onwards after our guide, tumbling and slipping and jumping, and swinging down the steep sides of the dingle, sometimes in the path of a running torrent, sometimes in the projecting fragments of slate, and sometimes where no path or way at all was visible. The thorns opposed our passage, the boughs dashed their drops in our faces, and stones frequently slipped from beneath our feet into the chasm below . . . By the time we had reached the bottom of the dingle, our boots were completely soaked, and so slippery that no reliance could be placed on steps taken in them. We managed, however, very well, and were amply rewarded by the beauty of the falls which now came in view. Before us was a chasm enclosed by high perpendicular and water-worn rocks of slate, from the sides of which sprang a luxuriant vegetation of trees, bushes, and plants. In its bosom was a basin of water, into which fell from above a stream divided into minute drops from the resistance of its deep fall . . . We stepped across the river on a few tottering and slippery stones placed in its bed, and passing beneath the overhanging masses ran round on projecting points, until between the sheet of water and the rock over which it descended; and there we remained some time, admiring the scene . . . No path was discernible from hence, and we seemed to be inclosed on a spot from whence there was no exit, and where no cry for help could be heard because of the torrent-roar.

Faraday was never sufficient until himself for religion, and church activities played an important part in his development. He was a member of a small and rigorous sect known as Sandemanians. To him there was no conflict between science and religion and he kept them distinctly apart. Apparently he enjoyed participation in the church and for years he was an elder and lay preacher. Through his church he met Sarah Barnard, the daughter of one of the elders, with whom he fell in love, and courted without unusual incident. The temporary effects of this courtship upon his usual serenity may be seen from a letter he wrote to her:

December 1820

My dear Sarah – It is astonishing how much the state of the body influences the powers of the mind. I have been thinking all the morning of the very delightful and interesting letter I would send you this evening, and now I am so tired, and yet have so much to do, that my thoughts are quite giddy, and run round your image without any power of themselves to stop and admire it. I want to say a thousand kind and, believe me, heartfelt things to you, but am not master of words fit for the purpose; and still, as I ponder and think on you, chlorides, trials, oil, Davy, steel, miscellanea, mercury, and fifty other professional fancies swim before and drive me further and further into the quandary of stupidness.

From your affectionate,
Michael

However, inept as he may have been in writing of his love, he was persuasive enough in other ways, and they were married in June of 1821. Even though they had no children, their marriage contributed much to his life for it enabled him to achieve serenity of mind needed to further prepare him for the great work he had yet to do.

Now he was 30 years old. He had learned all that his master, Davy, had to teach him; he had tested his power of observation, analysis, and expression. He was thoroughly competent to seek a fortune through commercial work or to pursue original research in the laboratory, but he was not yet ready. He needed to increase his knowledge of facts and to perfect his methods of judging them. So, for nearly 10 years he worked, wrote, and lectured. He rejected commercial opportunities. He gathered together all the historical experiments in electricity then existing and repeated them to his own satisfaction with his own hands.

At last, at nearly 40 years of age, he felt that he was ready. He took to his laboratory, and, on a lead furnished by Ampère, worked furiously for three months

(*Continued on page 56*)

*Preciseness of writing, coupled by close attention to detail and sharp observation, developed in Faraday a lucidity of written and oral expression which has been seldom equaled in scientific writing. He was a popular lecturer, and prominent personages were often in his audience. In this illustration are: the Prince Consort; the Prince of Wales (afterward Edward VII); Prince Alfred (later Duke of Edinburgh); the Reverend John Barlow; Dr. Bence Jones; and Professor Tyndall.*

*Keystone View Co., Inc.*

# Graduate Study at M.I.T.

*By* **JOHN W. M. BUNKER**

FROM the conception of post-baccalaureate study leading to an advanced degree authorized by the Corporation in 1872, through the award of the first such degree to a graduate student in 1886, to establishment of the Graduate School as an administrative unit in 1932, the notable record of its expansion in facilities, resources, courses of instruction, and enrollment through 1939 has been reported in The Review* by the late Harry M. Goodwin, '90, the first Dean of the Graduate School.

The succeeding decennium has been a period of further expansion and of consolidation. Expansion of numbers has been accelerated by the veterans returning to college and by other qualified applicants from all over the world eager to pursue advanced study in science, engineering, or architecture. The disintegration of universities in Europe has turned the attention of these students to America: the repute of our Alumni has focused this attention upon our Institute.

Within the Faculty, an assiduous cultivation of wartime advances in science and engineering has strengthened our curriculums. Likewise, the increasing awareness of the indispensability to the professional man of reasonable understanding in the so-called "humanities" has contributed to increased educational opportunities at the Institute, and in no sector has this increase been larger or more significant than in the Graduate School at M.I.T. These factors favor expansion.

Just as a tree needs both pruning and cultivation if it is to attain symmetry and to bear fruit, so also is it necessary to curb here and encourage there lest this 17-year-old Graduate School ramify in wild growth. Proliferation is yielding to planned and calculated consolidation.

Since 1898, the Faculty Committee on Advanced Degrees and Fellowships had been charged with administering the affairs of graduate students. From time to time it formulated rules for its own guidance, and in 1917 it set up a code for degree requirements for doctors and masters. In the latter category, it specified fields of study rather than course numbers, which designation, it recites, "gives a greater dignity to their work." Already the foundations had been laid for recognition that Course and Department constitute administrative conveniences and not separate entities in the broad areas of scientific knowledge.

* Volume 42, Numbers 4 and 5, February and March, 1940.

Currently this committee is known as the Committee on the Graduate School. It includes one member from each department offering graduate work, elected annually by the Faculty, with the dean of the Graduate School as its chairman, ex officio. It determines, subject to Faculty confirmation, the policies and procedures of the Graduate School, and exercises certain judicatory functions in respect to their interpretations, and enforcement of needful regulations.

The role of the Committee on the Graduate School, as it is in fact exercised, has developed a character that is uncommon among academic legislative or governing bodies. To this committee there is delegated by Faculty rules a high degree of responsibility and authority. Under its own Rules and Regulations, which have never been questioned by the Faculty, it is the duty of its chairman to "administer the affairs of the Graduate School under the President." It has always been the policy in regard to regulation of Graduate School matters to win espousal of principles rather than to exact compliance with regulations. This policy is in tacit agreement with the principle that in the administration of an educational program, little can be accomplished by rules and regulations alone, no matter how meticulously or comprehensively they are drawn. It is the skilled and informed interpretation of guiding principles by a student's adviser and teacher which affects most significantly the educational service which is offered. In this situation, as in most others, it is the substance and not the form which is important.

The most important function of the Committee on the Graduate School is exercised in its monthly meetings for consideration of proposals which affect the Graduate School as a whole. As a result of the free-for-all discussions in these sessions there are derived from time to time modifications and interpretations of objectives and policies in regard to the education of graduate students.

The promulgation of precise rules, and the detailed specifications of such matters as credits for subjects taken in this school or elsewhere, are kept to a minimum consistent with maintenance of standards and equality of opportunity for all candidates for a given advanced degree in any field which is appropriate for development at the Institute.

The tactics to be employed in meeting the requirements for a degree and the attainment by the student of his educational objective are delegated to those at the operational level, namely the departmental registration officers for graduate students. This results in a degree of individuality in programs of study that is advantageously different from the traditional, and to a large degree inescapable, characteristic of a prescribed core of essential subjects to be "passed" by all students in a specified sequence according to pattern.

Graduate student programs of study are subject to custom tailoring in the endeavor to secure a better fit to individual aptitudes and professional objectives of each student. These professional objectives are subject also to modification and alteration through personal counseling in light of the changing conditions in respect to employment needs and opportunities.

Fashion and vogue affect the choice by students of careers toward which they elect to point. It would be

naive to assume that each graduate student elects a particular field of specialization in science or engineering solely because of personal preference for that particular field: the question of a job after graduation cannot be ignored.

Thus, as an aftermath of World War II, unusually large numbers of young men presented with an opportunity for graduate study in science and engineering, aware of the great public interest in electronics and in nuclear fission, made these two fields by far the most popular choices for advanced study. Employment possibilities were great for competent men in each of these areas. The approach of supply to industrial demand has been greatly accelerated. Before some of these boys can finish one, two, three or more years of study for an advanced degree, employer demand will surely have become less pressing. It is a function of a graduate Faculty to keep its fingers on the industrial pulse and in anticipation of the attainment of a balance between supply and demand, to inform prospective students of an impending oversupply of professional personnel in any field.

On the other hand, accelerated developments in propulsion by application of energy in ways other than by the internal combustion engine have been recognized by research and development in the fields of fuels, jet propulsion, and gas turbines. Realizing our responsibility as a forward-looking school, there has been made available instruction in recent developments such as these for our students. We must choose when to encourage new vigor, and be alert against mere vestigial survival in our curriculums.

For 1948–1949 the total enrollment in the Institute was 5,400, of which number 3,800 were undergraduates, largely full-time students; 1,600 were registered as graduate students, slightly more than one half of whom were less than full-time students, as shown in Table I.

Head count (as in Table I) does not present a true picture of the effective size of the Graduate School because so many of its students are devoting only part time to study. Applying the appropriate discount factor in each case of a part-time graduate student, the approximately 1,600 students represent a requirement for educational service equivalent to the load imposed by 1,077 full-time students. The *effective* size of the Graduate School during the past academic year was 20 per cent of the whole student body. Ten years ago, the total registration in the Institute was 3,093; of these, 692 were graduate students, and most of them were carrying full-time programs of study. The ratio of teaching service for graduate students to total teaching service has, therefore, not increased during this period. This is not the result of chance but of planned controls.

**Questions often asked about the Graduate School include:**

**1. How large is it?**

**2. Is M.I.T. becoming primarily a graduate school?**

**3. Is teaching of undergraduates being relegated to graduate students?**

**The answers to these and other questions about advanced study at the Institute will be found in Dean Bunker's survey of the Graduate School for the 1939–1949 decennium.**

Our Graduate School, while stabilized as to maximum size for the present, is in no sense fixed in the scope of its educational opportunities. It is in a continuing dynamic state of change in the endeavor not merely to keep up with the times, but to anticipate probable future trends. These changes are initiated in, or approved by, the Committee on the Graduate School before presentation to the Faculty.

An example of one such fundamental change is the authorization by the Corporation in 1948 of programs of advanced study in the engineering departments of the Institute to meet the objective of affording more extensive preparation for professional engineering practice than is to be expected from a program leading to the S.M. degree, but without the emphasis on the bases, methods, and results of original research which characterizes the requirements for the doctorates of philosophy or of science. The final proposal as presented to the Faculty for its recommendation to the Corporation was the result of more than a year's study and examination of needs, facilities, ways and means, and even of semantics in respect to naming the new degrees. The result is a thoroughly considered plan to offer to engineers an opportunity to develop greater potential of professional competence (insofar as this can be developed in school) not through a sharpening of the specialization of the master of science but by broadening the base of understanding in areas ancillary to that of the major specialization.

The degrees, aeronautical engineer, chemical engineer, civil engineer, and so on, as granted by M.I.T.,

TABLE I

NUMBER AND EDUCATIONAL LOAD OF GRADUATE STUDENTS 1948–1949

| Full-Time Students 100% Load | | *Academic Staff-Students* Full-Time 33% Load | | ½ Time 60% Load | | ⅓ Time 80% Load | | *Special Graduate Students* 2-6 Subj. Ea. 100% Load | | 1 Subj. Ea. 0 Load | | TOTALS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vet. | N-V. | Vet. | N-V. | Vet. | N-V. | Vet. | N-V. | Vet. | N-V. | Vet. | N-V. | Vet. | N-V. |
| 399 | 372 | 159 | 155 | 126 | 95 | 38 | 9 | 13 | 19 | 142 | 70 | 877 | 720 |
| 771 | | 314 | | 221 | | 47 | | 32 | | 212 | | 1597 | |

recognize not a mere intellectual veneer from two terms of electives on top of a master's program: on the contrary, they recognize the satisfactory completion of a well-integrated program with a broad base of pertinent subjects culminating in a final demonstration of the student's ability to choose wisely from extensive resources the means for solving professional engineering problems such as he is likely to encounter in his later life, the whole program comprising at least two years of planned advanced study beyond a baccalaureate.

This demonstration may take the form of a comprehensive examination, or the solution of an engineering problem that will call upon the student's sources of information, or it may be a thesis of similar characteristics. The decision in each case is left to the department in which the student is enrolled. Each student in the Graduate School is enrolled for registration convenience, in some one department, usually in that in which the principal subjects in his major field are offered. The subjects approved for his registration must constitute an integrated program of study and may be selected from those offered in any department, provided their subject matter is pertinent or contributory to his educational competence in his major field.

There is, of course, a hazard in too great a degree of specialization. A professional man spends about one third of his life in the practice of his profession, about one third as a mere human being in sleep, but there remains a third for his life as a citizen. No man can live unto himself alone. Just as there is no place for national isolationism, so also there is no satisfying existence for the individual isolationist. If a college boy thinks of this aspect of his future at all, he may comfort himself with the good intention of becoming informed about literature, the fine arts, sociology, and his obligation as a citizen after he becomes established in his career. To be sure, many effective citizens have done so, including those who have not been fortunate enough to have shared a university life.

There is a tendency for a professional school to become preoccupied in professional education. It may be asserted, with reason, that scientific education induces habits of analysis and reasoning that equip a man to intelligently examine and solve any type of problem. It is true also that one must and can educate himself. As Abbott Lawrence Lowell once said: "Every capacity worth having can be developed only by personal effort, and brought to a high point only by carrying the effort far . . ." Nevertheless, it is equally true that intellectual, as well as physical, expertness can be attained more effectively in a given time under expert coaching than by self-teaching.

With other reputable engineering schools the Institute includes in its undergraduate curriculum a definite amount of class work in English, history, economics, and the Humanities. A planned sequence of such studies has been prescribed since 1945, replacing the former elective General Studies. It seems reasonable therefore to require of graduate students, who receive advanced degrees from M.I.T., at least a substantial amount of similar studies. If this requirement has not been met elsewhere, it must be satisfied while enrolled in the Graduate School by election of undergraduate subjects or by participating in graduate seminars in the Humanities.

The graduate seminars in Humanities are an experiment in education. They have been established for graduate-student participants only. They are limited to 20 men each and constitute a joint inquiry and discussion under the leadership of an outstanding expert in such fields as reading of famous books, problems in philosophy, economic and industrial history, economic problems, international affairs, and psychological concepts. No grades are given. No final examinations are held. The goal of expert knowledge is substituted for attainment of academic marks. A student who does not pull his oar is dropped from the squad. A senior colleague coaches his juniors.

In at least one seminar, successive classes have petitioned to be allowed to continue their study with their instructor. This appears to be an encouraging departure from didactic instruction, ingestion, and regurgitation on final examination day, which too often is followed by complete forgetfulness once the grades are in.

The master of science was the terminal degree for most of the 240 engineers who were awarded degrees in June, 1949: those receiving the doctor of science numbered 30. Of the nonengineers, 40 received the doctorate of philosophy as compared with 11 masters. One degree of electrical engineer inaugurated the award of this degree, and for the first time, the graduates of Course XIII-A received the new degree, naval engineer. These figures are reasonably typical of the current preferences for terminal degrees at the Institute in engineering and science.

In order to operate at the highest possible level of usefulness, a school must possess not only able and skillful teachers but also a student body capable of learning to the extent and at the speed which will utilize the services available. To the Faculty of M.I.T. there is accorded the pre-eminence which it deserves. Its student body is maintained at a high level of capacity through selective admissions.

To the Graduate School there are currently admitted about one half the number of our citizens who apply, and about one quarter of foreign applicants. The maintenance of a favorable differential between numbers of applicants and of admissions is not an evidence of intellectual snobbery; it is a condition that insures a student body of such high caliber that the most able are not held back by laggards. Rarely does a teacher so submerge his sympathies as to point his instruction solely to the best students. It is common knowledge that the progress of a section is governed by the slowest in the group.

While it must be conceded that there is need in the technical world for service in the ranks as well as at the officer level, it is not efficient for a leading educational institution to operate as a school for privates if there are available sufficient candidates of appropriate capacity to train for leadership. To be sure, the subsequent careers of its Alumni, whether they remain in the rank and file or whether they advance to leadership depend upon many factors not controllable in school, but the experience in school can determine

whether or not it will be possible to realize opportunity for advancement when it presents itself. Under the stimulus of the intellectually able students now enrolled in the Graduate School, their professors are really going to town. This stimulus has a beneficial effect also upon their undergraduate teaching.

Foreign students, faced with the disruption of European universities in the war-ravaged areas, are turning to the United States. Those in science and engineering in large numbers turn to M.I.T. Before the recent restrictions on conversion of foreign currencies to dollars, the tide of foreign applications for admission to our Graduate School was tremendous. Faced with the necessity of establishing limits on acceptances, after wide consultation with officers of this and other institutions and governmental agencies, the proportion of 10 per cent of our total number of graduate students was picked as the upper limit of the extent to which it seemed fair that our own boys might yield places to their colleagues from other lands. This restriction, together with dollar shortages, has somewhat relieved the pressure, but there were in late 1949 a significant number of applicants with most persuasive credentials from other lands to whom we regretfully had to say, "Sorry, no more room this year."

Henry B. Kane, '24

*The Graduate House, adjacent to the Institute's main academic buildings, provides comfortable living for 453 of the Institute's graduate body.*

The academic excellence of the work of the foreign students compete on an equal basis has been won by fellowship and scholarship aid for which all graduate students compete on an equal basis has been won by as large a proportion of foreign students as of our own citizens. This is a healthy situation.

According to a recent publication of the Institute of International Education, of the 25,000 foreign students studying in the United States in 2,500 educational institutions in 1948–1949, M.I.T. with seven per cent of its total enrollment given to foreign students (graduate and undergraduate) leads all other schools in the extent of this hospitality. In actual numbers, it is in seventh place.

The academic grades of our graduate students as a whole are higher than those of our undergraduates as a group. This has occasionally been misinterpreted to indicate less rigorous standards or excessive sympathy upon the part of instructors of the more advanced group. This is definitely not the true explanation. When one considers that graduate students represent substantially the top third of baccalaureate holders, that these students have elected to invest time and dollars in advanced studies in fields of their own selection, it is apparent that in them there exists motivation and trained-study habits both of which contribute to excellence of academic performance. Were such a selected body of students not to earn higher average grades than those of the much larger numbers of undergraduates from whom they were selected, it would indeed be an arraignment of graduate-school instruction.

Associated with the idea of graduate-school instruction there is always the topic, research. To the uninformed, research may appear to be the significant difference between undergraduate and graduate study. The relatively greater importance attached to the thesis requirements of advanced degrees, over those of the bachelor's degree, contributes to this impression. By and large, graduate studies at M.I.T. prepare for professional practice in much larger proportion than for careers in research. This is illustrated by the distribution of advanced degrees awarded in June, 1949, as set forth above, and is emphasized by the establishment of the recent engineer degrees.

In successful professional practice in science, engineering, architecture, or management, problems constantly arise which must be solved by a marshaling of experience and by the elucidation of new facts. Research consists of solving of problems. The technique of reliable methods of effective research can be acquired, in the initial stages at least, most economically of time and with the least amount of wasted effort under skilled guidance, demonstration, and instruction. Research methods do have an important place in graduate training, but are not the major preoccupation of the graduate student nor of his teachers.

(*Continued on page 63*)

# Training for Family Living

***The Future of All Societies Depends upon the Integrity of the Family whose Aim Should Be the Perfection of Character***

**By M. F. ASHLEY MONTAGU**

THE family is in trouble, not only in America, but elsewhere in the world as well. In America, one in three marriages ends in divorce, whereas in England the ratio is one in five. Juvenile delinquency rates increase each year with predictable regularity. These are but two of the most conspicuous evidences of family disorganization. Meanwhile, father grows more tired, and mother's voice more shrill, while "Junior" and "Sis" go their own way to the uncomprehending bewilderment of their parents.

Modern parents often find it difficult to understand why their children aren't what they expected them to be. They blame the comics, the movies, the radio and television programs, and other commercial vendors of false values. Shocking and iniquitously bad as these incubi of the modern world so frequently are, in their hearts, most parents sense that something much more profound than these is responsible. They know not what, and they are confused, puzzled, and worried. Having explored every other possibility, occasionally parents will fall back upon a last quizzical, and generally rhetorical remark: "Maybe we're to blame. Maybe we haven't done the right thing."

It should be clear, however, that well-meaning parents who have done the best of which they are capable are not solely to blame if the children are pretty much what their parents have made them. Most parents try to do the best they know how by their children. That "best they know how" comes to them from the society in which they have themselves been brought up, quite as much as from the society in which they bring up their own children. Because the parents are the transmitters of the accepted values of society to their children, it is their responsibility to bend every effort to see to it that those values are substantially right. From wrong causes you cannot expect right effects. If potential parents are not taught how to produce well-integrated personalities in their children, whose fault is that, if not that of the society whose way of life sets the style and gives the wrong leads?

Society, if anyone, is to blame, not the parent. If any parent prematurely wishes to heave a sigh of relief at this piece of news, let him pause awhile, for while he may be exonerated of culpable guilt, he must remember that it is people like himself who make a society. All of us participate in the making of a society by the way we behave in it. And the way we behave has been largely conditioned by the way of life of the society in which we have grown up. This sounds pretty much as if man is caught in a circular trap from which there is no escape. For if he has been largely conditioned by society to behave as he does, how is he ever going to see the defects of what he has thus learned, and what is more, how can he ever transcend those conditions so that he may be in a position to change them?

Fortunately, the answer to those questions can be clear and unequivocal. Through thought alone, or merely by wishful thinking, at any rate, man may not be able to add a cubit to his stature. By putting his mind to work, however, there is very little that he cannot do, so far as the understanding and influencing of behavior is concerned. It is because man is capable of learning and modifying not only his own behavior, but also that of other people, that we have every hope for the future of mankind's happiness.

### *Each Life a Philosophy*

Every way of life is a philosophy of life. A way of life is what people do about the process of living – not alone on Sundays, but through every moment of the day. What a person does is what he believes, and what he does is behavior. Any act of a human being, as of any living thing, is behavior, so that what a person does is, in other words, the expression of his beliefs in behavior. What a person believes is what he does, not what he says. If you want to know what a person believes, observe what he does, and you will know what he believes.

Now, many of the things in our way of life in America that we take most for granted, and that most of us believe in, and therefore about which we behave in certain ways, are not all that they should be. It will pay us to ask some simple and direct questions.

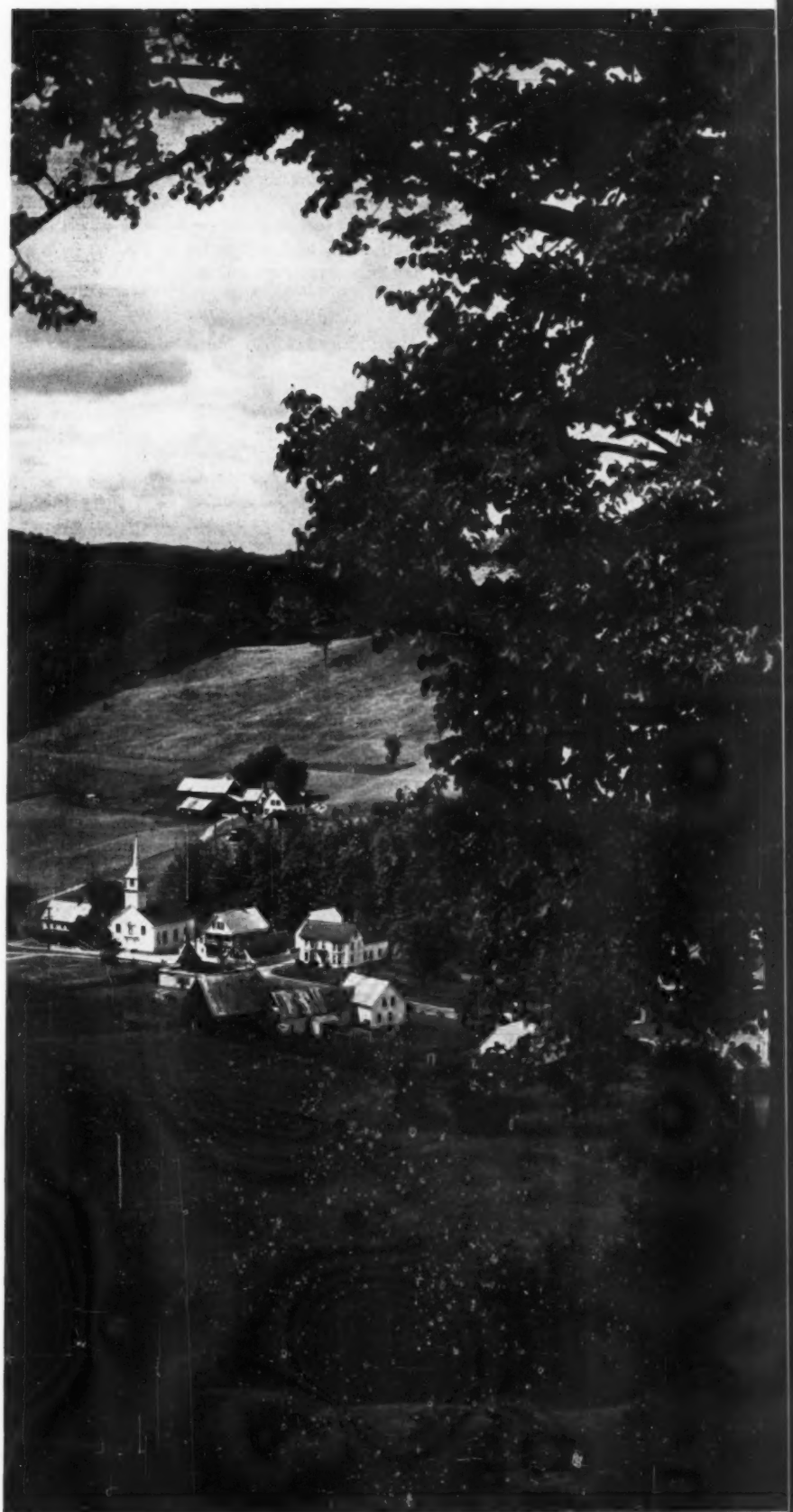
What is the dominant value or drive or goal in American life? What is it in this great land of ours that men want most? Think a moment. Yes, you are right. The driving force is success—money. Success, in this country, is usually measured in terms of money. When anyone says, "He's a very successful man," the image that statement usually creates is of a dancing series of dollar signs. A man's worth is measured not by his quality as a human being, but by the quantity of dollars he has managed to accumulate unto himself. Thus we come to the point at once. Our highest value in America, as in the entire industrial world, is a purely material one measured in terms of success and money. This is the operative value system of the world in which we live. This is the world into which we have been turned and into which our children, in turn, grow into social, striving, beings.

Whatever we may think and say to the contrary, spiritual values play very little, if any, part in our lives. The conviction of duty toward the Creator and toward one's fellow man is not manifest in our daily behavior. To love one's neighbor as oneself, fully understanding that whatsoever you do unto him you do unto yourself, forms no part of our daily practice. The consciousness of a common unity and a common purpose for all mankind is as far from accomplishment today as at any time in history. That all of us, in our great variety and diversity throughout the world, are God's children, and that "to *every* man belongs the worship and the glory" are thoughts to which lip service is given once a week, at most. That the greatest success is to be a good, loving, human being is rarely recognized and we never regard anything short of that as a failure.

Certainly all of you have heard these ideals expressed before. Most of us learned them, as one lad put it, at our mother's knee – and at other joints – at Sunday school, at church, and elsewhere. These ideals constitute a part of the faith of our society. They belong to the covert system of our beliefs, about which we may talk, but they do not belong to the overt system of our beliefs, about which we trouble to do something.

The trouble with modern man is that he has lost his spiritual faith, and replaced it with a disastrous faith in material things. Yet this materialism is the faith we teach our children. No matter what we wish our children to become, to a very large extent they do become what we are. And what we *are* is what we *do*, not what we say we are or what we tell our children to be. We are their models, and it is from what we do, not from what we say, that they learn.

It follows, therefore, that if we want our children to grow up to be good human beings, in the only



*When towns and villages formed the pattern of living in the United States, American family life was untroubled by many of the ills which now plague it. Today, with one quarter of the country's population living in cities of 100,000 or more, relatively few families enjoy the healthful, reposed living which this photograph of East Corinth, Vt., suggests.*

*David W. Corson from A. Devaney, Inc.*

sense in which goodness means anything, we had better take a good look at ourselves. Is it family-centered life that we are really interested in, or is it a self-centered life? Every parent must answer this question for himself. More pertinently, this is not a question for parents but for potential parents. Like Samuel Butler's answer to the question "Is life worth living?" he replied that the question should not be directed to a man, but to an embryo.

Children are exacting, exhausting, chore-creating. They cramp one's external activities, and limit the range of one's pleasures. They increase responsibilities and reduce the amount of caviar which one can put upon the bread by which, we are told, man cannot live alone. Furthermore, in the modern world there are many who believe that those who travel alone travel farthest and most rapidly, while those who have given hostages to fortune have hung so many millstones around their necks. There are so many people in our society today who have lost all understanding of the true nature of life, particularly of human life, that they consider the family an archaic and unnecessary institution. One result of this attitude is the increase in the number of couples who have no children; another is the (unsuccessful) attempt of the state to assume the parental role. For those of us who have children the problem remains: How can we integrate the family, and properly train our children?

The first thing to realize is that bringing up a family is a full-time job which most of us are attempting to do on a part-time basis. Like marriage, family life is the best and greatest test of a person's character which has ever been devised. Freud has said that there are three impossible professions: The first is psychoanalysis; the second, bringing up children; and the third, the government of nations. I am inclined to believe that most parents will regard the bringing up of children as the most impossible. For most people, devoting all one's time to the cultivation of one's children is an impossibility under modern conditions of life. But by a "full-time job" I do not mean devoting every minute of the day to the children. In any event, that would hardly be desirable. It is not the quantity but the *quality* of the attention which parents give their children which matters. Parents must have an awareness, much more of the time than many of them seem to have, that children don't just grow, and that it is the parental duty to take obligations toward their children and toward society more seriously than they have been doing, not alone in the past but also in the present.

### *Primary Requisite for Progress*

Parents, and even nations, must realize that the family itself is the highest of all the values of any society. Our attitudes (and attitudes are values) toward the family will determine the character of the family. Hence, a primary prerequisite for progress in the right direction must be a reconsideration, a revaluation, of our attitudes toward the family. No state, no institution, and no idea can ever take the place of parents within the family. If any of us have ever been disposed to think that the future points in the direction of non-familial life, we may as well abandon all such ideas. We now know enough to be able to say that the future must see the development of more, rather than less thoroughly integrated family life. The future of civilization — of all civilizations, and of all societies — depends upon the integrity of the family; and familism must become in itself a way of life, because it has prestige over other ways.

The exhausting domestic chores of mother, the absence of father from home during the greater part of the day, the fatigue of body and often of soul which he brings home with him at the end of the day, along with economic and other worries incident to daily living, would hardly seem to provide an adequate background against which to care for the characters or the souls of one's children. For I conceive the function of the family to be nothing less than that: the care of children's souls. The bodily needs of American children are at least as well taken care of as anywhere else in the world, though even here some improvements could be made. But further improvements in the child's physical welfare can wait upon the more important task. Meanwhile, what can parents do under the conditions of life in which they find themselves at present, more closely to integrate family life?

### *Satisfaction of Dependency Needs*

I should recommend first, that they love their children more. Of course I do not refer to the weak-charactered, overindulgence or overprotective "smothering" which frequently passes for love, or the refrigerated kind of formal affection which is brought out for use when the occasion is thought to require it. That kind of affection is not love. Love may be defined as the satisfaction of the dependency needs of the person. Every human being is born with, and subsequently acquires, needs for the satisfaction of which he is dependent upon other persons. By having those needs satisfied from earliest infancy by the mother, the child comes to identify the producer of satisfactions, usually the mother, with pleasure. In this way it comes to love the mother, and in so doing takes its first step toward becoming a social human being. By being loved, it learns to love others. A child that has not been loved, never learns to love other human beings, and throughout its life remains a defective human, an inadequate social being. Such a person is incapable of warmth, is cold and awkward in his social relationships, craves affection more than anything else in the world, but is quite incapable of returning it. There is no known psychotherapeutic means for turning such a person into a warm human being.

If such damage can be done to the developing person within the first year or two of life, damage of a not dissimilar kind can be done to the child that has been adequately loved in infancy, but inadequately loved during later childhood and adolescence. In accordance with the definition given above, inadequate loving is here used to mean the inadequate satisfaction of the needs of the child.

One way of looking at a need is as a problem which requires solution. Do we do our very best to solve the problems which our children present to us? Do we do all that we can to help them solve their problems? Let

(*Continued on page 58*)

THE INSTITUTE GAZETTE

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# Science and the Humanities

***President Killian's Report to the M.I.T. Corporation Calls for a Fusion of Science and the Humanities without Weakening Either***

FOLLOWERS of activities at M.I.T. may be expected to evince more than usual interest this year in the President's Report which was presented to members of the Corporation at its regular meeting on October 3. It is, of course, the first such annual report to come from the Institute's new president and it reflects the touch of the skillful writer, as readers of The Review would anticipate. But in recounting the progress which has been made during the last year under his presidency, Dr. Killian has found opportunity to set forth his philosophy of education: He calls for "better linkages between science and the humanities, with the object of fusing the two into a broad humanism . . ." and believes that education should aim to "strengthen the aristocratic virtues of personal dignity, self-reliance, and self-understanding." It is this philosophy to which Technology Alumni and educators must look for a preview of educational things to come at M.I.T. In this issue, The Review is pleased to present a comprehensive condensation of those portions of the Report which deal with the year in retrospect. A later issue will deal with student life and statistical information of special interest.

Recalling the stimulating effect of the Mid-Century Convocation last spring, when he was inducted as the Institute's 10th president, Dr. Killian expressed the hope that the Institute "can continue to sponsor an increasing number of meetings which bring together the scholar and the public and which afford opportunities for representatives from education, public life, industry, and other fields to come together for comprehensive discussions of current problems, both technical and general."

The Convocation prompted many other observations, two of which are singled out for special mention by President Killian:

1. During the past half century, specialization has been an outstanding characteristic of scholarship and professional activity. The tactics and strategy of intellectual advance have required specialization, and specialization has moved from one triumph to another. The tactics and strategy of the second half century will require a specialism equally strong but tempered by less isolationism among scholars and more linkages between fields of scholarship. We know that in science the boundaries between sciences are becoming less and less definable and that overlapping sciences, such as biochemistry and geophysics, reflect in their vigorous growth the interdependence of specialized investigations. We find, too, that in our university organization we must devise new organizational methods, such as interdepartmental laboratories and programs, in order to provide an integrated approach to fields such as nuclear science, international relations, electronics, and public administration. In his authoritative study, *The Universities of Europe in the Middle Ages*, Rashdall* concluded that the true university is "a place where the different branches of knowledge are brought into contact and harmonious combination with one another." Our goal today is to achieve this harmonious combination and intercommunication.

Similarly, we need better linkages between science and the humanities, with the object of fusing the two into a broad humanism that rests upon both science and the liberal arts and that does not weaken either. We need a bifocal vision to thread our way among the problems of modern society.

If we can achieve such intellectual integration, the basis of the conflict between general and specialized education will have been removed. In fact, we have long passed the stage where there can be any legitimate debate over the competing effectiveness of specialized and general education. Both are essential. General education alone can result in superficiality and dilettantism; specialization alone, in narrowness and social myopia. To achieve a working partnership, however, requires an end to narrow jurisdictional differences in education. President Baxter at our commencement exercises last June spoke eloquently of the need for flinging more two-way bridges between the liberal arts and the sciences. The colleges must bring about this two-way traffic if they are to educate men who can, as specialists, bend specialism to the broad needs of our society.

2. My second observation prompted by the Convocation is that education, if it is to serve a free society, must not only train men who can do the complex, specialized work of society; it must also cultivate in these men a reverence for the dignity of the individual. Someone has said that democracy is most effective when it tries to make all its citizens aristocrats. It might also be said that education in a democracy is most effective when it strengthens the aristocratic virtues of personal dignity, self-reliance, and self-understanding.

Men with these qualities resist all forms of statism and Stalinist totalitarianism that regiment and depreciate the individual. Men with these qualities are also more immune to fear and frustration. President Bixler suggested at the Convocation that our chief peril is a loss of faith in the power of mind to solve society's problems and a consequent tendency to pick scapegoats – as, for example, blaming science for society's ills. The education that helps men avoid these aberrations must possess a synthesis of the general and the specialistic that brings, within the limits of our knowledge, the whole of life into view.

* London: Oxford, The Clarendon Press, 1895.

## SIGNIFICANT QUOTATIONS FROM PRESIDENT KILLIAN'S REPORT

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***Membership in the Communist Party disqualifies teachers because it involves adherence to doctrines and discipline completely inconsistent with the principles of freedom on which American education depends.***

In our educational program at the Institute these considerations have great influence, and the Mid-Century Convocation served to point up and extend this influence. The fact that an institute of technology held a convocation that enquired so widely and deeply into the social problems of the mid-century is evidence of a vigorous humanism that recognizes the interdependence, unity, and social value of all useful learning.

During the past year there has been much activity in rebuilding Technology for its expanded role in post-war education and research. Since Review readers have already been made familiar with the major portion of this program, particular attention is given to those portions of the President's Report which have not already been reported in these pages, or which, for one reason or another, deserve once more to be emphasized.

*The Development Program.* Last November more than 300 members of the Committee on Financing Development met at the Institute and launched the organizational work of the campaign to raise a sum of $20,000,000 for M.I.T. The organizational work, as recorded in The Review, has now been completed, but "In the weeks ahead," said Dr. Killian, "we must concentrate on obtaining very large gifts from individuals; these are essential if we are to reach our goal."

*Industrial Liaison Office.* Of increasing importance in the Institute's program of education and research is closer co-operation with industry. Companies making substantial grants-in-aid to the Institute do so under an arrangement whereby the Institute undertakes to keep the companies systematically informed about research and educational activities at M.I.T. which are important to the business of the companies. "To insure that the Institute's obligations under these industrial grants are fully carried out," President Killian reported, "we have established an Industrial Liaison Office. The office is directly responsible to the president, and its policies and activities have been carefully studied by a committee representing the faculty and administration." The objectives and opportunities of the Industrial Liaison Office are described by Dr. Killian as follows:

> Large industries realize that their leadership tomorrow must stem from an awareness and understanding of the new scientific knowledge and techniques of today. For any one industry the fact applies not to one research field alone but increasingly to all the sciences and fields of engineering. . . .
>
> This situation, I believe, presents M.I.T. with a superlative opportunity for widened service to the industrial community. The Institute conducts a research program of such vitality and diversification that we may truly claim a unique position. There is no more logical institution than this to which industry should be able to turn for such assistance. I hope we may accept this challenge, and by our own devices see to it that the significance and potentialities of our active researches are made more readily evident to industry than has been the case in the past.

*The Educational Program.* In reporting to the Corporation on the Institute's educational program, President Killian spoke of the new engineering degrees recommended by the Faculty (The Review, **51**:518), the recently established Oak Ridge Engineering Practice School (The Review, **50**:386), the Sloan Fellowship Program (The Review, **51**:28). Co-operative undergraduate courses for the Departments of Mechanical and of Aeronautical Engineering, in which students have about 70 hours of practical experience in a particular industry, in addition to their academic work at the Institute, were also announced. The Department of Chemistry has initiated a course of study and research leading to the degree of doctor of philosophy in analytical chemistry, thereby placing this branch of chemistry parallel with inorganic, organic, and physical chemistry as a course of study for graduate students. Other developments in the educational program were described as follows:

> During the year the Department of Metallurgy, together with the Department of Mechanical Engineering, has continued the development of its Metal Processing program planned to bring into fruitful liaison the designer who must employ metal in a machine or structure and the metallurgist who is a specialist in metals. This program, as well as the whole broad field of metal fabrication, is assured of its fullest development at the Institute by Mr. Sloan's gift (The Review, **51**:577) of $1,000,000 for a Metal Processing Laboratory. Architectural plans are now being drawn for this building, which will be located on the south side of Vassar Street, adjacent to the Guggenheim Aeronautical Laboratory.
>
> The Committee on Educational Survey, appointed three years ago by the Faculty, has completed its study, and plans to report to the Faculty this fall. Without anticipating the conclusions of the committee, I can report now that it has conducted its studies in a manner that has stimulated the educational planning of the entire institution and that has already brought lasting benefits through the interchange of ideas which have been promoted throughout the Faculty.

Steps were taken during the year to restudy the objectives of the Institute's summer program, and (as recorded on page 36 of this issue), Walter H. Gale, '29, Associate Professor of Aeronautical Engineering, has been appointed director of the Summer Session. Finally, two colleges, Pomona at Claremont, Calif., and Wesleyan at Middletown, Conn., were added to the list joining M.I.T. in the plan for combined liberal arts and technological study. This brings to 14 the number of liberal arts colleges participating with the Institute in providing a liberal and technical education.

*Improvements in Facilities and Environment.* During the past year, many improvements in the Institute's facilities and environment have been made; in fact, the building program under way last year was the largest in the Institute's history, except for the period in which the new buildings in Cambridge were erected during World War I.

The Charles Hayden Memorial Library has been going up on schedule and that part of the library building which is to house the humanities departments was occupied in early August. The 277-acre estate of the late Colonel Edward H. R. Green, on Buzzards Bay, near New Bedford, has been used by students and Faculty during the year for recreation and study. Many other important uses for this estate are envisioned as soon as funds become available. In announcing another important property acquisition, President Killian stated:

> Of long-term importance in the improvement of our campus was the purchase last month of the "Tech Block," the building on Massachusetts Avenue opposite the Rogers Building. With the exception of the State Armory at the corner of Massachusetts Avenue and Vassar Street and the Technology Store, the Institute now owns all the frontage opposite our main educational buildings on Massachusetts Avenue.

The President's Report also dealt with progress in such new structures as the Supersonic Wind Tunnel (The Review, **51**:282, 575), the 12,000,000-electron-volt electrostatic generator (The Review, **51**:30, 41, 576), the Hydrodynamics Laboratory (The Review, **51**:284; 576), and the new Eastgate apartment building (The Review, **51**:171, 576) which have already been reported in these columns.

*Academic Freedom.* Turning to a matter of current interest, during the era of the "cold war," President Killian reaffirmed a policy formulated when he became president (The Review, **51**:432). Dealing with the problem of academic freedom, he said:

> Last spring a formal statement of policy was issued reaffirming freedom of teaching and investigation at the Institute. This statement also reaffirmed the Institute's unequivocal opposition to communism and to any external control of the teacher which requires him to distort his research or teaching in accord with any "party line" or dictates from without his own mind.
>
> Other educational institutions and groups, notably the Educational Policies Commission of the National Educational Association, subsequently took similar positions supporting the freedom of the scholar and declaring that membership in the Communist Party disqualifies teachers because it "involves adherence to doctrines and discipline completely inconsistent with the principles of freedom on which American education depends."

## *Welcome, 1953*

THE most encouraging trend in student life since World War II has been the trend toward social maturity, James R. Killian, Jr., '26, President, told members of the entering Class of 1953 at a dinner of welcome in Walker Memorial on September 15, as approximately 700 students from about 46 states and 60 foreign countries converged on Cambridge to begin their studies at M.I.T. Dr. Killian's address was the first event in a new kind of extended week-end program planned to acquaint freshmen with the Institute's objectives, its facilities, and its personnel.

In his welcoming address President Killian stressed his conviction that in 1949 no college can shirk the responsibility of preparing a man to be a citizen as well as to make a living. "We believe," he said, "that scientists and engineers and architects must be more than narrow specialists if they are to perform their proper functions in modern society. They must have the breadth and judgment, the background and understanding, to be leaders in their professions and their communities."

He added that education is to be found not only in the classroom and laboratory but in the experience of living with one's fellows and in the acceptance by students of the fullest possible responsibility for managing their own affairs.

The Institute's freshman week-end program, the largest in its history, was attended by 550 members of the entering class of approximately 700. The program included tours of the Institute to familiarize the

*In three seasons out of four, winter being the exception, members of the M.I.T. Nautical Association take delight in maneuvering their dinghies on the Charles River.*

*M.I.T. Photo*

students with the buildings and laboratories, as well as demonstrations of the athletic facilities. Every freshman was given a directory containing photographs of the members of his class, an innovation designed to encourage student friendships.

At the dinner Professor B. Alden Thresher, '20, Director of Admissions, introduced Dr. Killian and other members of the administrative and academic staff, including: Everett M. Baker, Dean of Students; Thomas K. Sherwood, '24, Dean of Engineering; Professor John T. Rule, '21; George R. Harrison, Dean of Science; Professor Raymond D. Douglass, '31; Professor Francis W. Sears, '20; and Professor James A. Beattie, '17.

The week-end program was continued on September 12 at the Institute with talks by: William W. Wurster, '17, Dean of Architecture and Planning, who spoke on architecture and planning; John E. Burchard, '23, Dean of Humanities, who discussed the Institute's program in humanities; Professor Howard R. Bartlett, Head of the Department of English and History; Dr. Dana L. Farnsworth, Medical Director; and Colonel Harold R. Jackson, Head of the Department of Military Science and Tactics.

Following the morning program, members of the Freshman Class left by busses for Camp Wonderland for a two-day orientation program during which time they were addressed by members of the Institute's Faculty, heads of the student activities, and the various athletic coaches, who also arranged contests in baseball, rowing, and track events. They also heard talks by: Klaus Liepmann, Assistant Professor of Music; Pennell N. Aborn, in charge of student employment; and, in the evening, an address by Donald F. Carpenter, '22, formerly chairman of the Corporation Committee on Student Activity.

The Class returned to the Institute Sunday morning, September 18, and in the afternoon they attended a reception by President Killian for entering students and their parents.

## *For Summer Study*

WALTER H. GALE, '29, Associate Professor of Aeronautical Engineering at M.I.T., has been appointed to the newly created post of director of the Summer Session at the Institute as announced on September 25 by President Killian.

In making this announcement, Dr. Killian pointed out that the Summer Session Office, now established at the Institute under Professor Gale's direction, will be responsible for co-ordinating both the regular summer academic schedule, designed primarily to meet the needs of M.I.T. students, and special activities of outstanding value and benefit to others not associated with us during the regular school year.

The Institute's over-all objective in creating the new office is twofold: (1) to utilize the facilities of the Institute during the summer months to the advantage of industrial, technological, and scientific people who cannot participate in the Institute's year-round academic program; and (2) to provide parts of the regular academic program for members of the M.I.T. student body who wish to remain for study in Cambridge during the summer.

In commenting on the creation of the Summer Session Office, Professor Gale cited the Institute's successful experiences with special summer courses and conferences in such varied fields as textiles, ceramics, spectroscopy, and petroleum engineering. During the summer of 1949, courses designed especially for people from industry and government were held in food technology, and electronic computing methods; a six weeks' program of study for teachers of science in high and preparatory schools provided a review of fundamental subject matter combined with a survey of recent scientific developments.

Professor Gale has been a member of the M.I.T. Faculty since 1946, when he became associate professor of aeronautical engineering. He holds S.B. and S.M. degrees from the Institute, awarded in 1929 and 1930, respectively. He was a research assistant in the Department of Aeronautical Engineering at M.I.T. from 1930 to 1935, and served in the United States Navy in Washington, D.C. from 1942–1945.

## *Co-operation in Textile Studies*

TWO pioneers and leaders in textile technology, the Lowell Textile Institute and M.I.T., will pool their facilities beginning this autumn for the benefit of graduate and undergraduate students of New England's historic industry. Increased educational opportunities to students and an interchange of staff members of both institutions were assured in the plans for co-operation announced by Dr. Killian, President of M.I.T., and Kenneth R. Fox, '40, President of the Lowell Textile Institute.

This co-operative action covers mutual use of facilities for research and manufacturing at Lowell Textile Institute for M.I.T. graduate student theses, and use of M.I.T. textile division facilities for Lowell Textile Institute student theses, particularly at the graduate level; also, it covers the use of books, periodicals, and theses on textiles and the textile field in the extensive libraries of both schools.

By the agreement between M.I.T. and the Lowell Textile Institute, students of the latter may obtain additional work in chemistry, mathematics, business and engineering, and textile technology at M.I.T. Similarly, M.I.T. students will be given the opportunity of working with textile manufacturing and finishing machinery for cotton, wool, and rayon as summer session and other special courses become available at Lowell. The plans also contemplate the participation of staff members of both institutions in seminars and lectures in existing or in new courses.

For the students there will be regularly scheduled student trips from M.I.T. to Lowell and vice versa; and there are plans for joint meetings and interchange of information between student societies, such as the student chapter of the American Association of Textile Chemists and Colorists, and the Engineering Society.

Commenting on the plan, Professor Edward R. Schwarz, '21, in charge of Textile Technology at M.I.T., said: "The geographical proximity of the L.T.I. and M.I.T. and their common interests in textile education make it desirable that closer official co-operation exist between the two groups. For a number

of years funds have been available for graduate scholarships at M.I.T. for qualified graduates of L.T.I. through a grant by the Proprietors of the Locks and Canals on the Merrimac River. A number of recipients have completed requirements for the Master of Science degree in Textile Technology, including Kenneth R. Fox, now president of L.T.I. From time to time several faculty members of L.T.I. have taken special courses at M.I.T. in the field of textile research."

The program is in line with the Institute's objective of working as closely as possible with industrial problems in its educational as well as its research projects.

## *Harry M. Goodwin: 1870–1949*

THE death of Harry Manley Goodwin, '90, on June 26, 1949, marked the passing of a distinguished alumnus and emeritus member of our Faculty. His contributions to the Institute were marked by constructive originality and effectiveness as educator and administrator. Ever alert to the developments in his fields of physics and physical chemistry, he established in 1906, and headed, the first undergraduate course in America leading to the degree of bachelor of science in electrochemistry at M.I.T.

Drawing upon his own varied experience as a graduate student at Harvard and the University of Leipzig (Ph.D., 1893) followed by postdoctoral study at the University of Berlin, his noteworthy services on the Faculty Committee on Advanced Degrees and Fellowships of which he became secretary in 1907 and chairman in 1921, were recognized by his appointment as the first dean of graduate students in 1926 and six years later as dean of the newly established Graduate School of M.I.T.

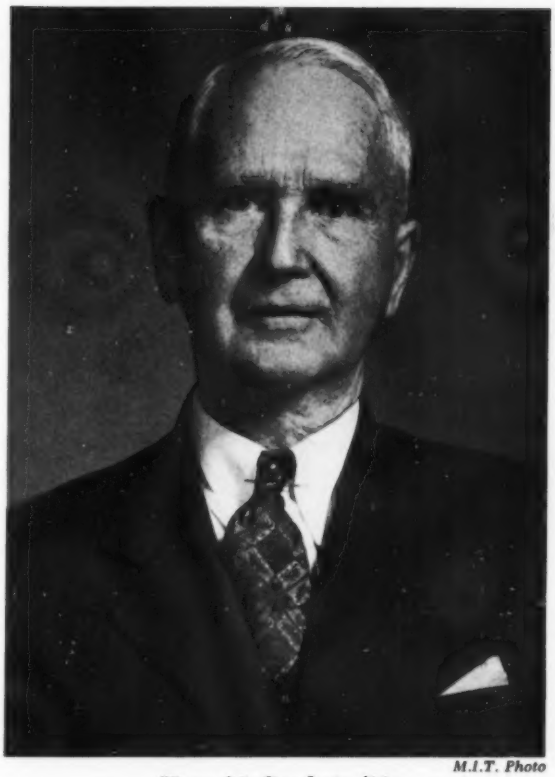
Upon his retirement because of calendar age in 1940, the Corporation conferred upon him the titles of Professor Emeritus and Honorary Dean of the Graduate School. His formal educational services to the Institute were completed as Honorary Lecturer in 1942.

Outside the Institute, also, his participation in matters pertaining to higher education were significant. As our first and continuing representative in the deliberations of the Association of American Universities, the record of his contributions is extensive and significant. Within the Institute, the organization of our Graduate School and the prestige which it attained under his administration are due in no small measure to his untiring and meticulous attention to the educational welfare of our graduate students.

Dr. Goodwin was a fellow of the American Academy of Arts and Sciences, which he served as librarian and vice-president, of the Washington Academy of Sciences, of the American Association for the Advancement of Science, and of the American Physical Society. He was also a member of the American Astronomical Society, and of Sigma Xi.

Always physically and mentally vigorous and alert, buoyant and friendly, but withal invested with unassuming but scholarly dignity, his memory endures in the hearts of his students and colleagues.

He is survived by his widow, Mary B. (Linder) Goodwin and by his son, Richard Hale Goodwin. His last message in the words of the following lines was read at his testamentary request to those who were gathered to do honor to him who had lived a full life.



*M.I.T. Photo*

Harry M. Goodwin, '90
*First Dean of Graduate Students at M.I.T.*

This life, where I have found enough to know,
And love, and hope for, and where all my work
Hath met as fair reward as I can wish,
Will end, as is ordained by laws whose source
Is hid to man. If any other world
Await me, I shall play my part therein
The better for this earth's experience.
Should this life be my last, then welcome rest!
I do not long to go, and do not fear.
I would not have my death cause needless grief,
Or fan the flames of strife I sought to quench.
No friends shall meet to listen round my bier
To pride dogmatic, claiming it has solved
The problems I would have men lay aside,
As far beyond our utmost reach of thought.
Nor would I be a theme for eulogy
Extravagant, by one who knows me not;
And yet I trust my friends would not consent
To see me laid away, without a word
To tell where they may look for strength and peace.
Some friend who knows how rich this life may be
In loving ties, kind deeds, and noble thoughts,
What treasure science opens to patient eyes,
What joy we find in making others glad,
What peace of mind awaits us as we rise
Above the strife of creeds, how bright this earth
Becomes to him who will not be the slave
Of superstition or of vice, shall show
To those who love me, as they meet to see
Me laid to rest, the grandeur of this life,
The sanctity of earthly duties, bliss
Which purity and wisdom give us here!
A nobler requiem I cannot ask.

Fay Foto Service, Inc.

*In addition to other activities of the Alumni Day week end, the Class of 1899 celebrated its momentous 50th reunion at a dinner which was held at the Hotel Sheraton in Boston on June 10, 1949. Thirty-two individuals commemorated this event pictorially as shown above.* Continuing back from the foreground, at extreme left: *Brainerd Taylor, Hervey J. Skinner, George C. Glover, George H. Priest, Harold S. Graves, H. Russell Sawyer;* seated at left of table: *Arthur H. Brown, Bernard Herman, Harry S. Mork, Timothy C. O'Hearn, Frederic B. Stearns, Harry K. White, Thomas P. Robinson;* seated at right of table: *Carroll W. Brown, Frederick C. Waddell, Miles S. Richmond, Henry C. Eaton, Edwin A. Packard, Benjamin E. Morse (deceased August 6, 1949), William S. Newell, George H. Perkins, Miles S. Sherrill, Leighton R. Rickards, '33, William A. Kinsman, Etheredge Walker.* Standing, from left to right: *Arthur L. Hamilton, Burt R. Rickards, Percy W. Witherell, E. Everett Pierce, David C. Churchill, Walter R. Bean, and Charles A. Smith.*

## *Recommendations by the Military*

At a dinner and evening meeting in Boston on December 6, 1948, the Visiting Committee on the Department of Military Science and Tactics* first discussed the problem of joint operation of the Army and Air Force Reserve Officers' Training Corps units at M.I.T. So far, the two services have maintained units integrated into a single operating organization with one professor of Military Science and Tactics, one administrative office, and one supply division. However, word had been received that after June 30, 1949, the Air Force would administer and operate its own Reserve Officers' Training Corps program.

The Committee is of the opinion that joint operation of the Reserve Officers' Training Corps program by the two services should be continued. This should insure better acquaintance, understanding, and practical co-operation between the two services, and also should result in greater economy of operation. In the joint program, each Reserve Officers' Training Corps student should be indoctrinated with the concept that he is a member of Armed Forces Reserve Officers' Training Corps, in which the Army, Navy, and Air Force are closely integrated. Care should be taken to avoid an appearance of subordination of one service to another.

The Committee also considered the question of whether the Army and the Air Force should both continue their Reserve Officers' Training Corps programs at M.I.T., or whether only one of the departments should have such a program at the Institute. This is part of a larger national problem as to whether the Army and the Air Force should operate Reserve Officers' Training Corps units at the same colleges, or whether their units should be located at different colleges. The Committee believes that Reserve Officers' Training Corps units of both departments should be continued at the same institution, where size and other considerations warrant. This arrangement provides the student a wider choice from which to make his selection of a service, takes full advantage of the variety of courses in which the students are trained, and is an aid to the promotion of better understanding and co-operation between the future officers of the Army and the Air Force.

The Committee briefly reviewed the method of providing uniforms to Advanced Course students. The method in use at M.I.T. provides for the purchase of uniforms by the use of funds advanced by the bursar of the Institute, and reimbursement to the Institute in accordance with current regulations on uniform commutation, after the uniforms are procured and issued. This entails a loan by the Institute of approximately $20,000 for a period of several months. It is believed that the Armed Forces should make arrangements for financing the purchase of uniforms, or otherwise eliminate the necessity for private institutions to carry this load. The Committee was informed by General Collins that legislation is now being considered which would provide for issuing uniforms to Advanced Course students, and dropping them from the records

(*Continued on page 40*)

* Members of this Committee for 1948–1949 were: Thomas C. Desmond, '09, chairman, Lieutenant Colonel Herbert S. Cleverdon, '10, Raymond H. Blanchard, '17, C. George Dandrow, '22, Colonel Benjamin S. Kelsey, '28, General J. Lawton Collins, and Major General Frank A. Keating.

# BUSINESS IN MOTION

## *To our Colleagues in American Business . . .*

In coal mining, air is sometimes used instead of explosives. A perforated steel cylinder is inserted in a hole drilled in the coal seam, and air at a pressure of 10,000 pounds per square inch is suddenly released into the cylinder. The explosive force of this high-pressure air is sufficient to disrupt the coal, and do it safely. Air shooting can be used in the same area where men are at work, so that it is unnecessary to stop operations in a large section when shooting.

The air is compressed above ground, and is led to the underground working face through steel pipe. There has to be a flexible connection between the end of the steel main and the perforated cylinder, for ease in handling, and to take the recoil when the pressure lets go. The connection is a copper tube whose specifications are quite different from those of the Revere tube used in such applications as radiant panel heating, refrigeration, plumbing. This tube for the coal mine is special tube indeed, for it is .375 inch in diameter, with a wall .120 inch thick. Thus the inside diameter is less than a third of the outside diameter. When we received the first inquiry for such tube our curiosity was aroused; the proportions seemed strange until we learned that a pressure of 10,000 pounds per square inch had to be withstood. Then we realized that we had before us another example of the fact that copper is an amazingly versatile metal.

Copper is believed to be man's oldest metal, but Revere likes to consider it as "the metal of invention", because it has so many admirable qualities that there seems to be no end to its uses. New ones keep coming up. However, there are other good materials too, such as steel, used in this case for the mains between compressor and coal face. The important thing is to use the best material in view of all the circumstances involved in fabrication and use. Producers of raw and semi-manufactured products know a great deal about them and are delighted to put their knowledge at the disposal of prospects and customers. Revere suggests that now is a good time to review specifications with suppliers; some advantageous new uses may be found for old materials in new forms, or new materials may offer improvements in old applications.

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## THE INSTITUTE GAZETTE

(*Continued from page 38*)

as "expended" when the students graduate. If this legislation is passed, it will solve this problem.

It appears to be the policy of the departments of the Army and of the Air Force to transfer enlisted Reserve Officers' Training Corps instructors from this duty at the end of about three years. Since a man attains his maximum value as an instructor after about one year of duty, the Committee believes it to be desirable that such men be retained on this duty for a longer period if practicable. It was pointed out by General Collins, however, that replacements for men returning from overseas garrisons are urgently required and that it has therefore been found impracticable to permit enlisted instructors to remain on Reserve Officers' Training Corps duty for more than three years.

Attention was given to some of the local needs of the Department of Military Science at M.I.T. The most important needs discussed can be summarized as follows:

(a) At the present time the rifles used by the Reserve Officers' Training Corps cadets for drill purposes are stored in the eastern extremity of the basement of Building 1. Since drill is necessarily held on Briggs Field, or in the Rockwell Athletic Cage, or the Armory, all of which are west of Massachusetts Avenue, considerable time is consumed by the students in picking up their rifles and proceeding to drill. Moreover, it is impracticable to use the rifles on rainy days, since they get wet while being carried across Massachusetts Avenue. A storage space for rifles in the vicinity of the new Rockwell Cage would eliminate this difficulty.

(b) There is a long-standing need for a new rifle range. The present range is wholly inadequate in size, and its condition is far below the building standards of M.I.T. In spite of this situation, the M.I.T. students have been outstanding in rifle competition. A 25-firing-point rifle range would take care of present needs.

(c) Another urgent requirement of the Department of Military Science and Tactics is more office space.

Accordingly, the Committee recommends:

(1) That insofar as M.I.T. is concerned, a policy be adopted of advocating the continued operation of both the Army and the Air Force Reserve Officers' Training Corps units at the Institute, and also joint operation of the two to the maximum extent practicable.

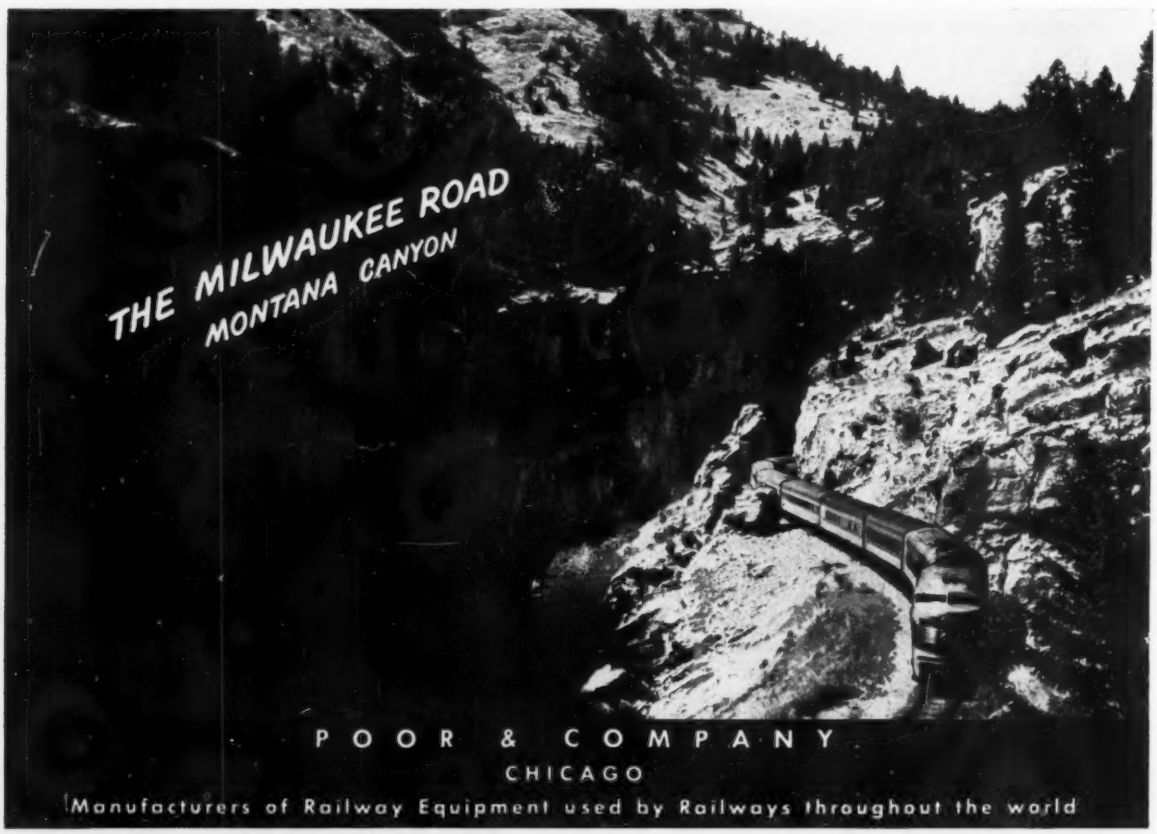
(2) That the proposed legislation referred to by General Collins be considered as a completely satisfactory solution to the uniform problem, and that no further action be taken on this matter at present.

(3) That a heated room or building be constructed in the vicinity of the Rockwell Athletic Cage for the storage and maintenance of rifles used for drill.

(4) That a 25-firing-point indoor rifle range be constructed as soon as practicable.

(5) That the Department of Military Science and Tactics be provided additional office space as soon as practicable.

(*Continued on page 42*)



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## THE INSTITUTE GAZETTE

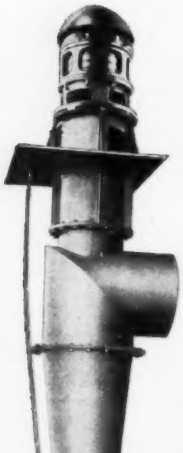
*(Continued from page 40)*

### *Architecture Surveyed*

In general, the problem facing the School of Architecture and Planning seems to be how to deepen and improve instruction in its own fields of specialization, without sacrificing some of the advantages of being part of a major scientific institution. This is one of the conclusions of a report, released for publication last summer, by the Visiting Committee on the School of Architecture and Planning.* The Committee's suggestions revolve around the relationship between this School and the Institute as a whole, with particular reference to the framework of requirements for all students that is aimed more at technologies of engineering and pure science than at technologies of the nature of architecture and planning. The Committee believes that the School is doing an outstanding job in both Architecture and Planning because of the strength of its own faculty and curriculums and because of the strength it draws from being a part of the Institute. The recommendations which follow are an effort to strengthen it still further.

*(Continued on page 44)*

* Members of this Committee for 1946–1947 were: Ralph E. Flanders, chairman, Harry J. Carlson, '92, John T. Howard, '35, William E. Hartmann, '37, William Emerson, George F. Keck, and George Nelson.



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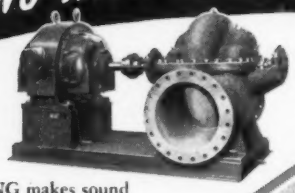

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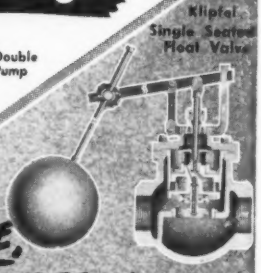

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*The Leyden Jar*

Between 1745 and 1750 divers Europeans were experimenting excitedly with The Leyden Jar. Dr. Priestly declared its discovery to be "the most surprising yet made in the whole business of electricity."

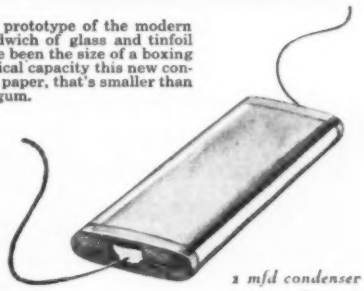
Early in 1747 Peter Collinson, fellow of the Royal Society, sent an "electrical tube" to his friend, Benjamin Franklin, in Philadelphia. As usual Dr. Franklin had some ideas of his own* and used a Leyden Jar in his famous lightning-kite experiment. It was Franklin who identified the principle and improved on the jar with the simple "Franklin Pane," a piece of glass with tinfoil on each side. Today's condensers are practically piles of Franklin Panes.

*Puckish old Ben even made a "magic portrait" of the King out of metal on glass with a removable crown. When an uninstructed person attempted to remove the crown he received a "tremendous shock." This served as a warning for too ardent patriots.

# *That's better Dr. Franklin, but–*

*The Franklin Pane*

The "Franklin Pane," prototype of the modern condenser, was a sandwich of glass and tinfoil and would have to have been the size of a boxing ring to equal in electrical capacity this new condenser, made of Smith paper, that's smaller than a package of chewing gum.



*1 mfd condenser Actual size*

# *–this one will go in your pocket*

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Smith has been making very thin papers for years — papers as thin as .00025 in. With the growth of electronics Smith's condenser paper became a product of considerable industrial importance.

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So, with 1/50 of the conductor and a half (or less) of the insulator the new Smith paper saves about 75% in the bulk of the finished condenser. Such a decrease in size and increased life expectancy are great advantages to all makers of television and other electronic equipment.

Isn't it cheaper to make a better product than to promote an ordinary one? We at National Research believe, by the evidence of our own experience, that it is. And we also believe that in the unexploited uses of industrial research lie the greatest opportunities for profit now offered to industry. To industry — to *your* business — we can bring the best in brains, organization and equipment with an unequalled accumulation of experience.

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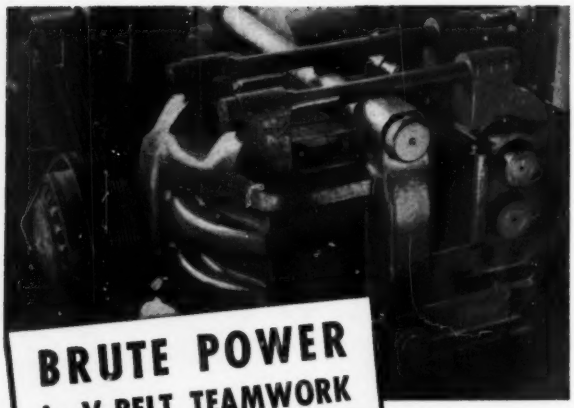


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(*Continued from page 42*)

The Committee believes there should be no effort to separate students in this School from the rest of the Institute body in the common freshman year. It does believe, however, that some modification of the freshman drawing course might be possible and desirable — not only to make it a better preparation for later work in this School, but also to increase the flexibility and usefulness of drawing as a tool for engineers and scientists.

The Committee feels, however, that there should be less rigidity in the Institute's uniform requirements, especially in physics and mathematics in the curriculums for upper-class students. The Committee recommends that consideration be given to the development of a science program permitting completion of the general courses in physics, chemistry, and calculus in the first year. This would make possible earlier courses in architectural drawing, architectural history, or visual design, which, as a result of the establishment of the common freshman year and of the present second-year requirements, are now pushed into a later stage of the curriculum than is desirable for a logical sequence of professional education. It is understood that this recommendation is now under study by the Administration.

The Committee also suggests elimination of physics and calculus requirements for graduate students coming from other institutions, as unnecessary prerequisites to the graduate curriculums in Architecture and Planning. A more generally worded science prerequisite would permit substitution, in some cases, of material more directly related to these fields, without compromising Institute standards.

The Committee lays considerable stress on the need to advance the professional courses mentioned above into the second year. It also considered the desirability of providing more background in architectural drawing for students of City Planning, especially those transferring from other institutions without training in graphic design and presentation.

## *Marine Engineering*

At its last meeting, held at the Institute on April 25, 1949, members of the Visiting Committee on the Department of Naval Architecture and Marine Engineering* met with administrative and teaching staff of the Department, inspected the facilities of the Department, and took note of progress which had been made since its previous meeting in 1948.

The Corporation has determined to proceed with the construction of the Hydraulics Laboratory Building which will include a towing tank 106 feet long, 8 feet and 7 inches wide, and 4 feet deep. When completed the new Hydraulics Laboratory will make a

(*Continued on page 46*)

* Members of this Committee for 1948–1949 were: William S. Newell, '99, chairman, Ellis W. Brewster, '13, Roy W. Chamberlain, '31, Eugene P. Worthen, '32, Victor M. Cutter, Vice-Admiral Earle W. Mills, and John E. Slater.

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His vision widened the horizons not only of his own organization, but of the whole power field. His pioneering work in the field of pulverized coal firing and water-cooled furnace walls was an outstanding achievement that initiated the widespread use of pulverized coal in power stations throughout the world. This work was recognized in 1943 by his selection for the Percy Nicholls award, a joint award of the American Society of Mechanical Engineers and the American Institute of Mining Engineers for "notable scientific or industrial achievement in the field of solid fuels."

Combustion's long-range research and development program, under the direction of Mr. Kreisinger, contributed importantly to the advanced engineering features characteristic of the complete C-E line of steam generating, fuel burning and related equipment. And because today's experiment may well be tomorrow's standard practice, Combustion is constantly exploring new frontiers at its laboratories where the successors to Mr. Kreisinger devote their talents to carrying on his objective "To find the truth and apply it." 8-336

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2 Dry Type Air Cooled Transformers
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3 Constant Current Regulators *(Static Type)*

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## THE INSTITUTE GAZETTE

*(Continued from page 44)*

substantial contribution to the research facilities of the Department. The Hart Nautical Museum has been completely rearranged, redecorated, and new lighting has been installed. A series of models showing the development of ocean-going sailing craft is quite complete, and the collection of naval craft is fair, but the group showing development of steamships is not satisfactory, nor are there any good models of modern merchant vessels except in very small sizes. Steps are in hand to correct these deficiencies, but limitations of space, funds, and staff make progress slow.

The most serious problem now confronting the Department is that of providing adequate drafting-room space for the growing body of graduate and undergraduate students. Some relief for such space problems is mandatory and the problem is under study by the Administration.

With the completion of the Hayden Memorial Library, certain departments of the Institute will move to the new building, making more space available in Building 5 for the Department. Space now occupied by the Dard Hunter Paper Museum is recommended for use as a drawing room for the Department of Naval Architecture and Marine Engineering.

The reassignment of the Pattern Shop to the Department and its redesignation as the Ship Model

*(Continued on page 48)*

*Reg. U. S. Pat. Off.*

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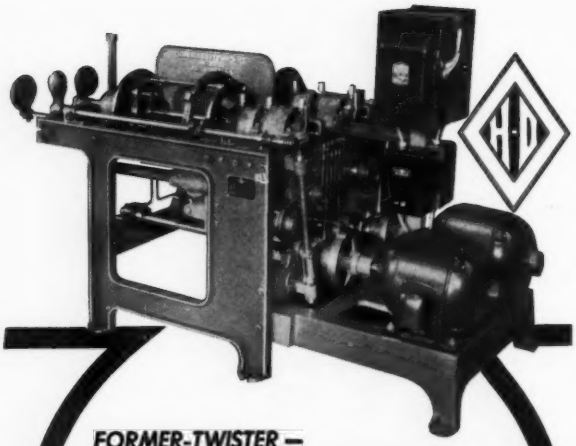

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## THE INSTITUTE GAZETTE

(*Continued from page 46*)

Shop are viewed with favor by the Committee. This Shop forms an essential element in the towing-tank project and is an important one in the normal activities of the Department.

In response to the suggestion of Thomas K. Sherwood, '24, Dean of Engineering, the value of Course XIII-C was fully explored. It was the unanimous opinion of the Committee that there is a need for such a Course, and that it should be continued, if qualified staff to handle it can be maintained. The graduates of the Course are filling an increasingly important niche in the field of marine transportation on the basis of a curriculum unique in its composition.

At present, students of Course XIII-C are required to spend a full year of experience in the marine industry, with at least nine months spent at sea. Generally, this is taken as a fourth year in the Course. The Committee feels that this is more than is required, and that adequate practical observation and experience could be gained by having students spend two summer vacations at sea working on shipboard. Students can be placed in suitable sea billets for such practical summer work, and the plan would be agreeable to the industry. It would, of course, save a year in the student's training and give the Institute better control of the student's training time. The Committee therefore recommends this change in the curriculum.

The Committee found a healthy spirit and continued progress in the Department. The faculty is materially stronger than in the past, and the work done is of increasing breadth and competence.

### *Student Activity*

STUDENT activities at M.I.T. are in a sound, healthy condition, according to the latest report of the Visiting Committee on Student Activity.* Following the disruption of the war period, all the significant activities have been re-established, and many have been added. Ninety-three separate activities are recognized formally by the undergraduate governing body, the Institute Committee.

Interest in student government has developed to a current postwar high point, and your Committee is favorably impressed with the caliber, enthusiasm, and competence of undergraduate administrators in the direction of student government affairs. The tradition of undergraduate responsibility for undergraduate matters seems firmly renewed.

A student Judicial Committee established last year, with jurisdiction in situations involving disciplinary problems, is another evidence of traditional M.I.T. policy of student responsibility. Last year M.I.T.'s Interfraternity Conference won the award of the National Interfraternity Conference as the "one in the United States which during the previous year had

(*Concluded on page 50*)

* Members of this Committee for 1948–1949 were: Raymond Stevens, '17, chairman, Henry E. Worcester, '97, H. W. McCurdy, '22, and J. Willard Hayden.

# "The one field that offered exactly what we wanted"

*Charles I. Lytle and family, Buffalo, N. Y.*

During the years I was in the Army, I often thought of having a business of my own, and this was in the back of my mind when I returned to civilian life.

Before the war I had worked for a large paint company, and upon my discharge, I returned to them, serving as manager of one of their stores. But within a year I resigned, mainly because what I really wanted was a position where my income would be measured by my ability — not by what someone thought I was worth. And where I could exchange my energy and talents for good living conditions for my family, and for an unlimited opportunity for me to earn.

Some serious, long-range thinking brought me to the conclusion that the one field that offered exactly what I was after was life insurance. So I contacted a number of companies here in Buffalo, and spent several days studying their respective merits and histories. I was impressed with the caliber of New England Mutual men I met, and by the fact that this company had always led the field in providing liberal policyholder benefits.

That's why I joined New England Mutual. Now, after my Home Office training course, and with the valuable help of my General Agent and the many aids offered to New England representatives, I'm making steady progress. I've got that business of my own, and it's providing the opportunity for me and the good living conditions for my family that we've always wanted.

Charles I Lytle

**These Massachusetts Institute of Technology men are New England Mutual representatives:**

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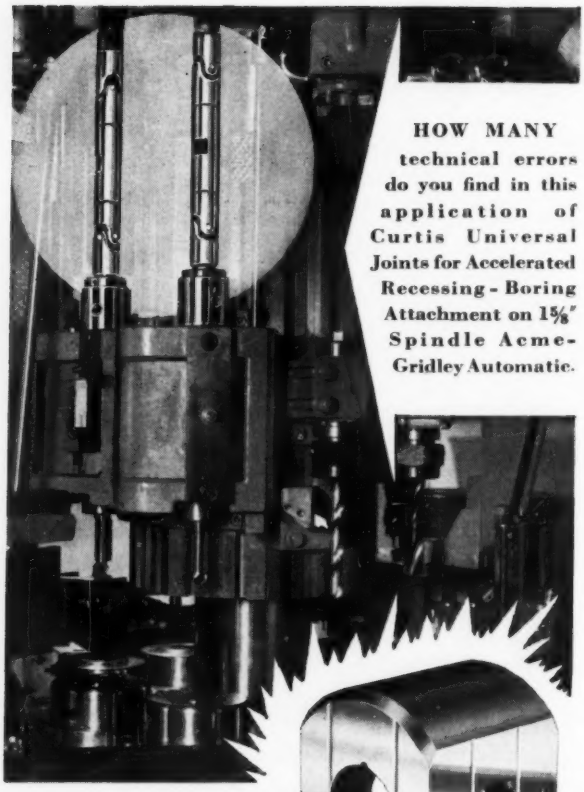

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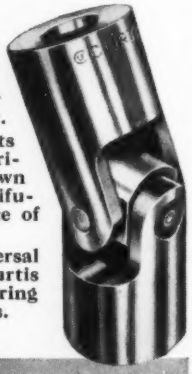

CURTIS UNIVERSAL JOINT CO. INC. SPRINGFIELD MASS.


## THE INSTITUTE GAZETTE

(*Concluded from page 48*)

made the most notable contribution to the social and educational program of the institution."

Since the Corporation recorded its interest in, and support of, adequate provision for student housing, recreational and extracurricular activity, notable progress has been made in improving the physical and social facilities available to the student outside the classroom and laboratory. An example is the recent appointment of a director of Dining and Housing Facilities, reporting to both the treasurer and to the dean of students. The director is expected to attack and improve that area of the student environment falling under his jurisdiction. There will always remain much to be done, however. It is apparent that administrative headquarters and general housing for student nonathletic activities are still inadequate. They should receive some relief with the opening of the Hayden Library and its humanities quarters. Facilities scheduled in the program of the Committee on Financing Development will find capacity demand the moment they can be made available.

Most serious is the fact that more than half of the undergraduate body lives off the campus. Many of the steps taken for improving student environment must be, and remain, an inadequate approximation of the ideal until the time comes when more adequate and more suitable campus housing is made available. In the meantime, your Committee is most favorably impressed with the progress being made within the facilities and funds at hand.

## THE TREND OF AFFAIRS

(*Continued from page 22*)

to withstand great extremes of temperature as well, but in any case the mechanical design of a rugged tube is strictly governed by the required electrical properties.

The Bureau's facilities for testing the ruggedness of electron tubes now include vibration apparatus, mechanical resonance testers, high-impact shock machines, and high-speed centrifuges. Some tests are conducted with typical electrical potentials applied to the tube elements so that noise modulation, short circuits, and other effects can easily be studied. Destructive field conditions can be reproduced through the proper choice of vibration, resonance, impact, and acceleration tests.

After receiving various ruggedness tests, tubes are examined for structural failures. X-rays are sometimes used to reveal the extent of structural changes without opening the tube envelope. Materials for certain tube elements are examined spectroscopically to determine their exact composition and to find impurities that might weaken the tube structure. This determination of the real causes of tube failure is an important part of the rugged tube program. Out of these studies

(*Continued on page 52*)

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## THE TREND OF AFFAIRS

(*Continued from page 50*)

will come recommended specifications for materials best suited to particular ruggedization problems. In some cases new materials and new methods of fabrication must be developed to meet the unusual requirements of ruggedization.

### *The Principle of the Hollow Charge*

THERE have recently appeared a number of peaceful, if spectacular, applications for one of the oddest effects known to the science of explosives. This is the hollow-charge principle, known in one form or another since 1792, but more popularly in this country as the Munroe effect (after Charles Edward Munroe, American chemist and educator, 1849–1938), and in Germany as the Newmann effect.

The phenomenon first attracted wide attention when the United States and Germany almost simultaneously began the use of rocket projectiles launched from recoilless guns known as bazookas. Although these projectiles were much slower than shells from orthodox antitank guns, their ability to penetrate armor was devastating. Actually the projectiles themselves did little penetrating and their velocity at impact was a quite minor factor in their success. Covering a cone-shaped hollow in the front of the charge was a thin metal liner, and as the relatively small amount of explosive detonated, the shock wave was focused to move parallel to the axis of the cone, collapsing the metal liner into a molten jet that moved ahead at tremendous speed. Velocities for these jets of up to 30,000 feet per second have been reported – about 10 times that of a fast rifle bullet.

The action of this jet on steel has been compared to that of a water jet acting on soft mud. So high are the dynamic pressures associated with these extreme velocities, that the ultimate strength of a metal is relatively insignificant by comparison, and a mild steel stands up almost as well as a heat-treated alloy steel. In fact, one of the suggested applications is in creating, for short time intervals, the extremely high pressures useful for studying certain properties of materials. Pressures of over 3,000,000 pounds per square inch appear feasible.

Since the outstanding characteristic of the shaped charge is its ability to blast a deep hole of rather limited diameter, it has been tried in various mines as a substitute for drilling. The hole formed by the shaped explosive (which must be of the military types that give high order detonations) is then packed with standard mining explosives just as if it were a conventional drilled hole. Whether the process is generally economic remains to be demonstrated.

Another interesting application is in perforating oil well casings to open up the surrounding rock structures and increase the flow of oil. Explosives have been used before, but to drive more or less conventional projectiles through the steel walls and into the local strata. With the Munroe effect, the projectile can, of course, be dispensed with. In view of the lim-

(*Concluded on page 54*)


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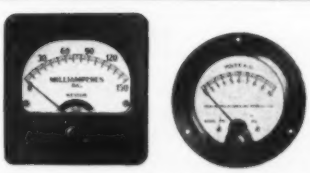
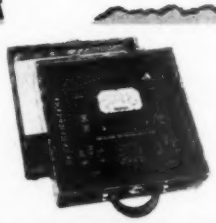
*(Model 798) MULTI-PURPOSE TUBE-CHECKER* offering provision for testing Receiving Tubes — Voltage Regulator Tubes—Light Duty Thyratron Tubes such as 2A4—6D4—884—885—2051. Scale is calibrated "Good-Bad" as well as in mutual conductance range.



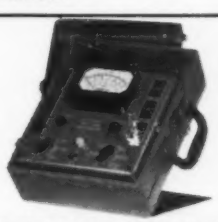
*PANEL and SWITCHBOARD INSTRUMENTS* a complete line of instruments in all types, sizes and ranges required for switchboard and panel needs . . . including DC, AC power frequencies and radio frequency, rectifier types and D.B. meters.

*(Model 697) VOLT-OHM MILLIAMMETER* one of a line of pocket-size meters, Model 697 combines a selection of AC and DC voltage, DC current, and resistance ranges. Ideal for maintenance testing and many inspection requirements.



*(Model 785) INDUSTRIAL CIRCUIT TESTER* a versatile, portable tester for laboratory or maintenance needs, where an ultra-sensitive instrument is required. Provides 27 AC and DC voltage, AC and DC current, and resistance ranges. (DC sensitivity 20,000 ohms per volt.)

*(Model 779, Type 1) SUPER-SENSITIVE ANALYZER* small, light, compact, 26 range Volt-Ohm-Milliammeter with 5 DC voltage ranges, sensitivity of 1000 or 20,000 ohms per volt. AC temperature compensated. Self-contained power supply. Ideal for many production and test requirements.



*(Model 769) ELECTRONIC ANALYZER* incorporating a conventional Volt-Ohm-Milliammeter with self-contained power source—a high-impedance electronic Volt-Ohmmeter using 115 volt, 60 cycle power—a stable, probe-type, Vacuum Tube Voltmeter, for use to 300 megacycles.

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## THE TREND OF AFFAIRS

*(Concluded from page 52)*

ited room existing in a well casing, obtaining more penetration for the same amount of charge may be a matter of some importance.

The most recently reported application, however, is so close an analogy to military usage that one wonders whether the sword is being beaten into a plowshare or is being used to stir the forge as is. Shaped charges are being used experimentally to tap blast furnaces and open hearths. In the past, the tap holes, plugged with solidified metal, were opened by bar and sledge hammer, a hazardous manual operation. More recently, the oxygen lance has been used to burn through a hole at the time when tests showed the heat analysis to be correct or when it was time to pour for other reasons. Even with the oxygen lance, accidents can result if the tap opens more rapidly than expected, or blows out. Or it may take more time to get the metal flowing than expected, while the superintendent stands around fuming impatiently. With the shaped charges, an insulated tube about ten inches long, two and a half inches in diameter, and containing only about two ounces of explosive is mounted over the tap hole. When the proper moment arrives, the closing of a switch is followed immediately by a blast that punches a hole about three-eighths of an inch in diameter through a piece of cast iron up to eight inches thick.

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## PREPARATION FOR DISCOVERY

(*Continued from page 25*)

– then went to Brighton for a rest. From there he wrote to his friend, Richard Phillips, about what he had done.

Nov. 29, 1831

We are here to refresh. I have been working and writing a paper that always knocks me up in health, but now I feel well again, and able to pursue my subject; and now I will tell you what it is about. The title will be, I think, "Experimental Researches in Electricity"; I. On the Induction of Electric Currents; II. On the Evolution of Electricity from Magnetism; III. On a new Electrical Condition of Matter; IV. On Arago's Magnetic Phenomena. There is a bill of fare for you, and, what is more, I hope it will not disappoint you. Now the pith of all this I must give you very briefly; the demonstrations you shall have in the paper when printed.

### *Fame from Discoveries*

His fame immediately soared. Kings and emperors acclaimed his discoveries, but his preparations had only begun to bear fruit. Discoveries flowed from his laboratory for more than 20 years. They covered almost the whole breadth of physical science – electricity, magnetism, optics, chemistry, metallurgy. Notable among them were his works in electrochemistry, diamagnetism, the magnetic polarization of light, corrosion of metals, dielectrics, and his definition of specific inductive capacity and of electrochemical equivalents. All his works were executed and described so perfectly that many of them still stand firm as the foundations of modern science.

A particularly remarkable fact is that at no time did he feel the need of mathematics; he actually regarded mathematics as a hindrance – but only to himself, for he respected the use of it by others. On the other hand, mathematicians held Faraday in high esteem. Clerk Maxwell, who furnished the mathematical interpretation of Faraday's conception of electric and magnetic forces, said Faraday was: "a mathematician of high order, and one from whom the mathematicians may derive valuable and fertile methods." And von Helmholtz said: ". . . it is in the highest degree astonishing to see what a large number of general theorems, the methodical deduction of which requires the highest powers of mathematical analysis, he found by a kind of intuition, with the security of instinct, without the help of a single mathematical formula." Probably Faraday had developed a keen sense of quantitative relationships, even though he chose to express his results in a form free of symbolic notation.

### *Honors Bestowed*

As the years passed, his fame increased, but he maintained an even humility under the honors showered upon him. He declined knighthood and the presidency of the Royal Institution, stating that he preferred to remain plain Michael Faraday. Queen Victoria, aware of his lack of interest in money and his need for retirement, gave him a house at Hampton Court where he lived in contentment to the age of 76.

(*Concluded on page 58*)

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## processes and equipment for . . .

. . . the separation of hydrocarbons or other organic chemicals, should be designed for efficiency in terms of overall operating costs and amortization of capital investment. Tray efficiency, cleaning facility and resistance to corrosion are the principal factors to be considered. For practical purposes, tray efficiency or tray spacing may be reduced to keep tower cost at a minimum. A balance of utility costs against chemical recovery may indicate the desirability of sacrificing some of the recoverable material, with a corresponding reduction in the capital outlay for columns and associated calandrias, condensers and heat exchangers.

Particularly when potential changes in process or product specifications are foreseen, distillation columns with sectional shells and removable trays of light alloy construction offer special opportunities for economy because of the ease of transfer from tower to tower as well as cleanability and resistance to corrosion.

*Distillation column of type 316 stainless steel measuring 56 feet in height, 10½ feet in diameter, having six shell sections.*

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## PREPARATION FOR DISCOVERY

*(Concluded from page 56)*

When he died at Hampton Court on August 25, 1867, Faraday left a legacy of researches which laid the foundations for the great electrical age of today.

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## FAMILY LIVING

*(Continued from page 32)*

us ask ourselves whether we are part of our children's problem, or whether we are a part of the solution. Children need help in the solution of their problems, and they normally look to their parents for it. They want parental co-operation, because love is co-operation, and security, and they want to have and to be all these differently named things which are really the same thing. It is, above all other things, the function of parents to provide that love. We can go through all the motions of loving a child, perfectly believing that we love it, without in fact really loving it. Mush is not love, nor is love the exhibition of affection which is turned on and off as occasion requires. Love is a positive force and one which never fails. If you love anyone you cannot fail him. Don't talk about love. Be loving. Many of us are too offhand in our relations with our children. We don't have sufficient respect for them as persons, and instead of treating them as developing persons, we often behave toward them as if they were petrified forests of wrongdoing.

Human relationships are problems of adjustment, and that is the function which parents must serve to their children within the family. They must serve as adjusters who help their children to adjust and to adapt themselves to their problems. Where there is the desire to understand and to do this, a way will be found. Life itself is a continuous process of adjustment to changing conditions. And as some all-too-ex-

*(Continued on page 60)*


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| COX-3FS-014-GL | .014" cw. | .100" | 7.5 | 22.0 | 72 | Miniature |
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| COX-2FS-22-NL | #22 str. | .125" | 16. | 30. | 50 | diameter |
| COX-2FS-22-GV | #22 str. | .125" | 18. | 30. | 50 | flexible |
| COX-3FS-22-RS | #22 str. | .190" | 25. | 21. | 71 | cables |
| COX-3FS-026-GV | .026" cw. | .240" | 50. | 17. | 90 | Size of 59/U |
| COX-4FF-026-RS | .026" cw. | .250" | 45. | 14. | 88 | Equal to 62/U |
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| COX-2FS-20-GV | #20 str. | .165" | 35. | 36. | 52 | Equal to 58A/U |
| COX-1FS-16-GV | #16 st. AG | .185" | 38. | 46. | 25 | |
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| COX-2FS-12-GV | #12 st. AG | .425" | 140. | 30. | 52 | RG-87/U |
| COX-2FS-10-GV | #10 st. AG | .445" | 200. | 30. | 52 | RG-94/U |
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## FAMILY LIVING

(*Continued from page 58*)

perienced human being once remarked: The process of living is like playing a solo in public the first time you pick up a violin; you have to learn the music and how to play the instrument all at the same time.

It is, I think, obvious that the best place in which to train young people for family living is within the family itself. But, it seems to me that the basic values for family living will have to be taught to potential parents outside the family, as well as within it. No risks however, should be taken. Society is responsible for the value system of the family, and society should make itself responsible for seeing that the values best calculated to secure a happy and loving family should be made part of the behavioral equipment of every member of society. The task is certainly one for each family to undertake, but I believe it should also be the principal task of our schools to inculcate these values.

Training for family living should start at birth with two parents adequately equipped to give that training – by loving their children. As a second step in the progress toward integrated family living, we might well revise our view of what we like to call education. In most of our schools education is, in fact, nothing more than instruction, which is a very different thing. We tend to regard education as completely specified and summed up in the three R's, reading, writing, and arithmetic. But we tend to neglect the most important of all the R's – human relations. The experience of the human race makes it perfectly clear that there is no education worthy of the name unless it be education in human relations. It must be the task of the school, in co-operation with the parents, to provide such education. This co-operative task should begin in the nursery school, which children attend during the period from three to five years of age. The nursery school should become part of the public instructional system of every community. It is here that the parents can begin to collaborate with the school teachers in the education of the young. In thus educating the young, each learns from the other, and each assists in the enterprise of creating a character to which nothing that is human can be alien.

Our schools must be reoriented in terms of human values, and those values must be taught in a positive manner, as a way of life for everyday living. In short, our schools must become institutes for training in human relations, and education in the three R's must be regarded as secondary to this, their primary purpose. In a negative sort of way our schools have always given training in human relations, not perhaps so much by what has been said as by what has been done in them. The attitudes of teachers reflect the values of the day, and these have inevitably been transmitted to the children. Unfortunately, many of these values belong to the market-place kind of living reflected in such works as *How to Win Friends and Influence People*. It is good and highly desirable to win friends and influence people but our aim should be to do so not because we have something to sell but because we have something to give.

By co-operating, from nursery school to high school,

(*Concluded on page 62*)

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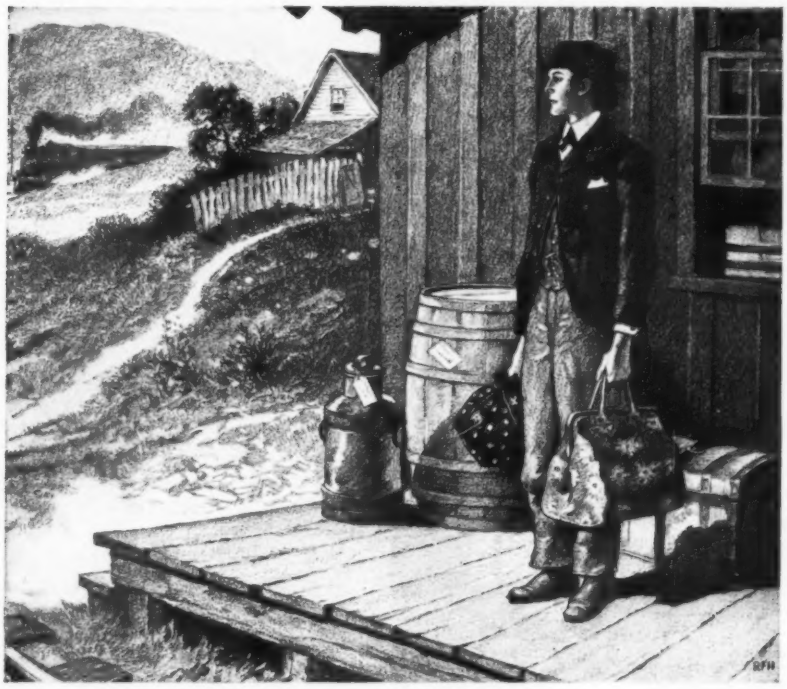

*To young men of the mid-19th century desirous of a fruitful career, the great editor, Horace Greeley, gave the now-famous advice: "Go West!"*

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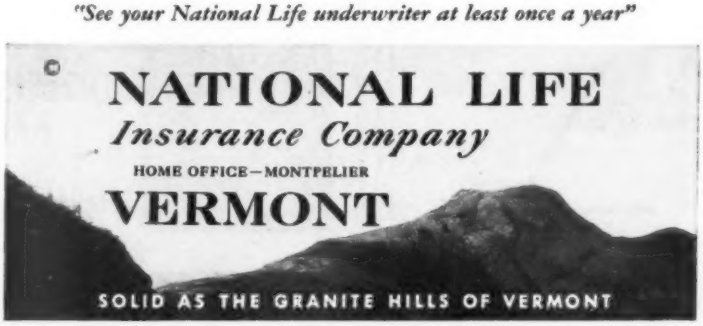


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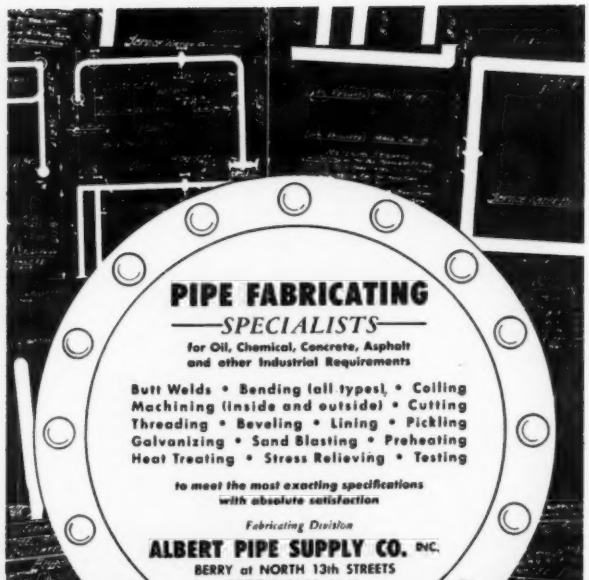
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## FAMILY LIVING

(*Concluded from page 60*)

with the teachers in the education of their children in the principles and practice of human relations, and in the humanizing of the three R's, not only will the children be educated but their parents also will be assisted.

At the present time some schools have courses in Home Economics, Marriage, and Family Living. At best these are but casual improvisations. What we mean to convey by such courses should be taught throughout the school life of the child. The time to begin teaching family living is in the nursery school, not in high school or college. In the later age grades, intensive courses should be given in which there are brought together, in an effective manner, all that the prospective parent and spouse should know in order to achieve a happy fully integrated family. So much for the schools and the parents in relation to the creation of the integrated family. What of religion?

Fifty-two and one half per cent of the American population are members of some religious organization. It is believed that this is a larger proportion than ever before. Nevertheless, it has been obvious for some time that many of us have been coasting along on a somewhat perfunctory obeisance to the ideas of the Christian ethic without much conviction or will to transmit the full meaning of that ethic to our children. All of us are acquainted with the spiritually rudderless person of today who finds himself adrift in a sea of conflicting values, unable to steer a straight course. Religion is a way of life. As such it is best taught in the family, and the church will co-operate. The good life as laid down in the simple tenets of each great religion should be taught in the home, so that every child may be provided with that spiritual rudder which he will need in order to steer his course successfully in relation to his fellow men. The ultimate purpose of all religious teaching, as most great religious teachers have seen it, is the perfection of human character. In this, the schools, the church, and parents can each serve to complement each other's work.

If we will train our young people for family living by these means and toward these ends, we shall have trained them for living with their fellow men everywhere, in love, in peace, in good will, and in happiness. This is the challenge of the day. And it is no less a challenge than to be or not to be. It is up to us to take it up, to deliberately construct that future, for upon what we do now the future of mankind depends.

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## GRADUATE STUDY AT M.I.T.

(*Continued from page 29*)

The significant volume of research being conducted under the leadership of members of our instructing staff provides a rich source of problems in which our graduate students may properly participate. The fact that financial support of these expensive researches is forthcoming from sponsors outside the Institute has, upon detailed examination, been found not to pose, per se, an educational problem.

The professorial research project supervisor is first of all an educator. In respect to graduate students assigned to particular problems incident to project research there is no educational problem as long as the supervisor keeps this primary obligation in mind. Projects come and go, but M.I.T. as an educational institution has permanence. Pride in maintaining its educational standards is present in its Faculty. These standards are not being sacrificed to expediency in prosecution of sponsored research which, after all, is an interesting and useful accessory, but nevertheless only an accessory, to our business of education.

### *Benefits of Team Research*

Large, sponsored research projects are often most effectively prosecuted by teams of research workers. It is trite but true to point out that the day of the Ivory Tower and its isolated scientific or engineering occupant are characteristic of the past. Graduate students should be and are, whenever appropriate, encouraged to learn at first hand that in team research the end results are often greater than the sum of their individual parts.

How a student's thesis, when it arises from a team research, is to be evaluated in terms of the classical requirement that it demonstrate ability to conduct original research, is a pedagogical problem that merits and is receiving serious study. Perhaps new criteria will evolve to meet what already appears to be established as a changed situation.

There is no doubt that instruction of graduate students is attractive to a university instructor. Moreover, personal research activities are a satisfying part of a professor's career. No one will deny that such professorial activity contributes to the potentiality of more effective teaching. However, research is not the appropriate vocation of members of our Faculty. No one is ever appointed to the Faculty solely for research

(*Continued on page 64*)

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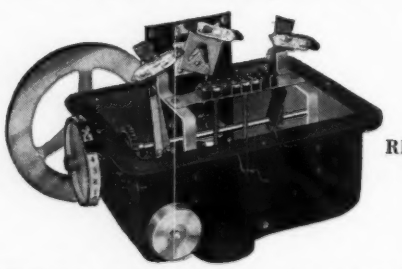

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## GRADUATE STUDY AT M.I.T.

(*Continued from page 63*)

activity: teaching service is always the primary expectation at the Institute.

Because of the relative size of the Faculty and our current student body, it is necessary for effective educational service to employ staff aides in handling routine aspects of laboratory preparation, correction of papers, and in some cases, responsibility for sections. These aides to teaching service are recruited in part from the more advanced and able graduate students who may receive term appointments as academic staff assistants. In the School of Science, certain of these are designated as Teaching Fellows. This is not to be construed as signifying that undergraduate instruction is being turned over to graduate students because of professorial preoccupation with research and graduate instruction. The distribution of staff members handling Freshman recitation sections in April, 1948, as shown in Table II, supports this conclusion.

TABLE II

DISTRIBUTION IN ACADEMIC RANK OF STAFF HANDLING FRESHMAN RECITATION SECTIONS IN 1948

| | *Number of Sections* | | | |
|---|---|---|---|---|
| *Academic Grade* | *English* | *Physics* | *Chem-istry* | *Mathe-matics* |
| Instructor | 13 | 7 | 0 | 18 |
| Research Associate* | 0 | 13 | 2 | 1 |
| Teaching Fellow† | 0 | 3 | 15 | 7 |

* Research Associates usually are candidates for a doctorate but are more mature than usual graduate students, often with extensive war-research experience.

† Teaching Fellows are half-time graduate students, usually doctoral candidates of proved attainments and an expressed interest in teaching.

Lectures in Chemistry 5·01 (general chemistry) were all handled by staff members of professorial rank; of 30 class sections, 12 were handled by professors, 2 by research associates, and 16 by teaching fellows. In Physics 8·01 (mechanics) all lectures were given by professors or instructors; recitation sections were assigned 10 to professors, 3 to instructors, 17 to research associates, and none to teaching fellows. In M11 and M12 (calculus), 6 sections were conducted by professors, 18 by instructors, and 6 by teaching fellows or assistants.

"A certain and not inconsiderable proportion of 'specials' will always constitute a desirable element in our body of students," wrote President Walker in his report for 1885. In 1948, more than 200 students were enrolled as Special Graduate Students (see Table I). These comprise a relatively small number who are pursuing studies elected to comprise an integrated program of study which does not conform to any stated degree requirements. Their objectives are judged to be sound and worth while. They are not would-be graduate students who could not make the grade. The majority are taking one subject at a time while in regular employment by the Division of Industrial Coöperation or outside agencies, and many are planning to later apply for regular graduate-student status.

(*Concluded on page 66*)

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## GRADUATE STUDY AT M.I.T.

*(Concluded from page 64)*

To quote further from President Walker: "To say of all the students of an Institution, that on penalty of foregoing instruction entirely, they shall take the whole of any one . . . course . . . is to demand what is a sheer waste of time and strength . . . (for) that comparatively small class of young persons whose intellectual aptitudes are so pronounced and peculiar . . . that they, generally speaking, should take up only those studies for which they have a distinct taste or fitness." These observations are as true today as they were 64 years ago.

The Graduate School renders effective public service in furthering the education of a significant group of young men who enter professional fields better equipped to develop useful citizenship than they would have been without the training which they here have received. The most that can be expected from this effort is to encourage in the student the habits of study and the degree of erudition that are necessary components of a useful life. Lest we become unduly prideful of their performance as Alumni, it is well to be reminded of the observation of Lord Melbourne in a letter to Queen Victoria: "Be not oversolicitous re education. It may be able to do much, but it does not do so much as is expected from it. It may mould and direct the character, but it rarely alters it."

On the other hand, there is reassurance in the words of Edmund Burke that: "No men can act with effect who do not act in concert. No men can act in concert who do not act with confidence. No men can act with confidence who are not bound together by common opinion, common affection and common industry." The Faculty of M.I.T., of which the Graduate School is only a part, are thus bound together. There is reason for confidence that, in the Institute today, there are being established the traditions of the future.


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# EXPLORE
# New Frontiers of Industry!

*By* EDWIN H. BROWN, *Vice President, Engineering Development Division*
*Allis-Chalmers Manufacturing Company (Graduate Training Course 1908)*

WILL IT WORK? Is it practical? Is there a *better* way to do it? If you feel the challenge in questions like these and get a thrill out of finding the answers — perhaps you're cut out for research.

EDWIN H. BROWN

There are a lot of us like that here at Allis-Chalmers. Pioneering beyond the immediate frontiers of industry has been one of the major factors in the growth of this company for over 100 years. Yet today we're finding more exciting frontiers to explore than ever before.

My part in this work started back in 1906 when I joined the Allis-Chalmers Graduate Training Course, from the University of Nebraska. During my two years in the course, I spent a good deal of time on the test floor. That's the spot where original thinking, new designs, and new methods pay off in results. It's a great vantage-point from which to watch industrial development at work.

**Measuring cavitation resistance** of various materials for pumps and hydraulic turbines. Material under test is electronically vibrated at a high rate while submerged in water.

After completing my GTC, I worked as a test engineer . . . as development and sales engineer on steam turbines . . . as a chief engineer and department manager . . . and into my present work in research and development.

### Unusual Range of Activities

Research here at A-C covers a tremendous range of industrial fields. I might point out that product development is considered a responsibility of each product department, while the central research and development organization works with the many departments in a staff capacity. Since Allis-Chalmers produces important machinery for every basic industry, you can see that our development work is extremely varied.

It includes such things as methods of burning coal deposits underground, to produce power without the intermediate steps of mining, processing and transporting the fuel to power plants. We're developing equipment for the application of atomic power in naval vessels. Working closely with engineers of the Turbopower Development Department, we're developing gas turbines for ship propulsion and high-temperature gas turbines for locomotive service, burning powdered coal.

Other engineers and scientists are engaged in pure physical research into factors that influence power transmission over long lines. There's constant departmental research and product development going on in the fields of flour milling, ore processing, water conditioning, hydraulic turbine design, electronics, new manufacturing methods and techniques, industrial design.

### Pick Your Spot

Graduate engineers selected for the Allis-Chalmers Graduate Training Course have a unique opportunity to explore many engineering and industrial fields, and find the work that suits them best. Here, you help set your own course—may change it as you go along and special interests develop. You can gain first-hand experience with almost any major industry you can name—electric power, mining, wood products, hydraulics, public works. You can work in machine design, research, manufacturing, sales engineering. You can earn advanced degrees in engineering at the same time. When you finish the course, you know where you're headed— and you're on your way!

*Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin*

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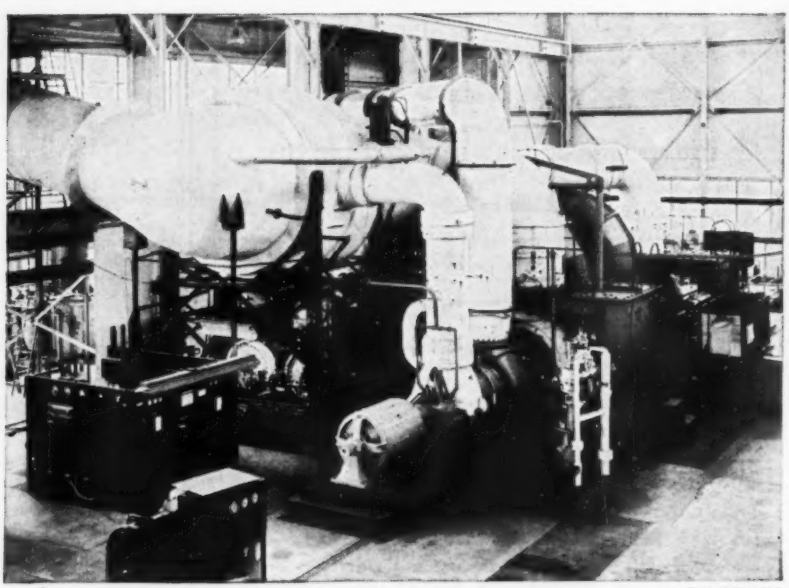
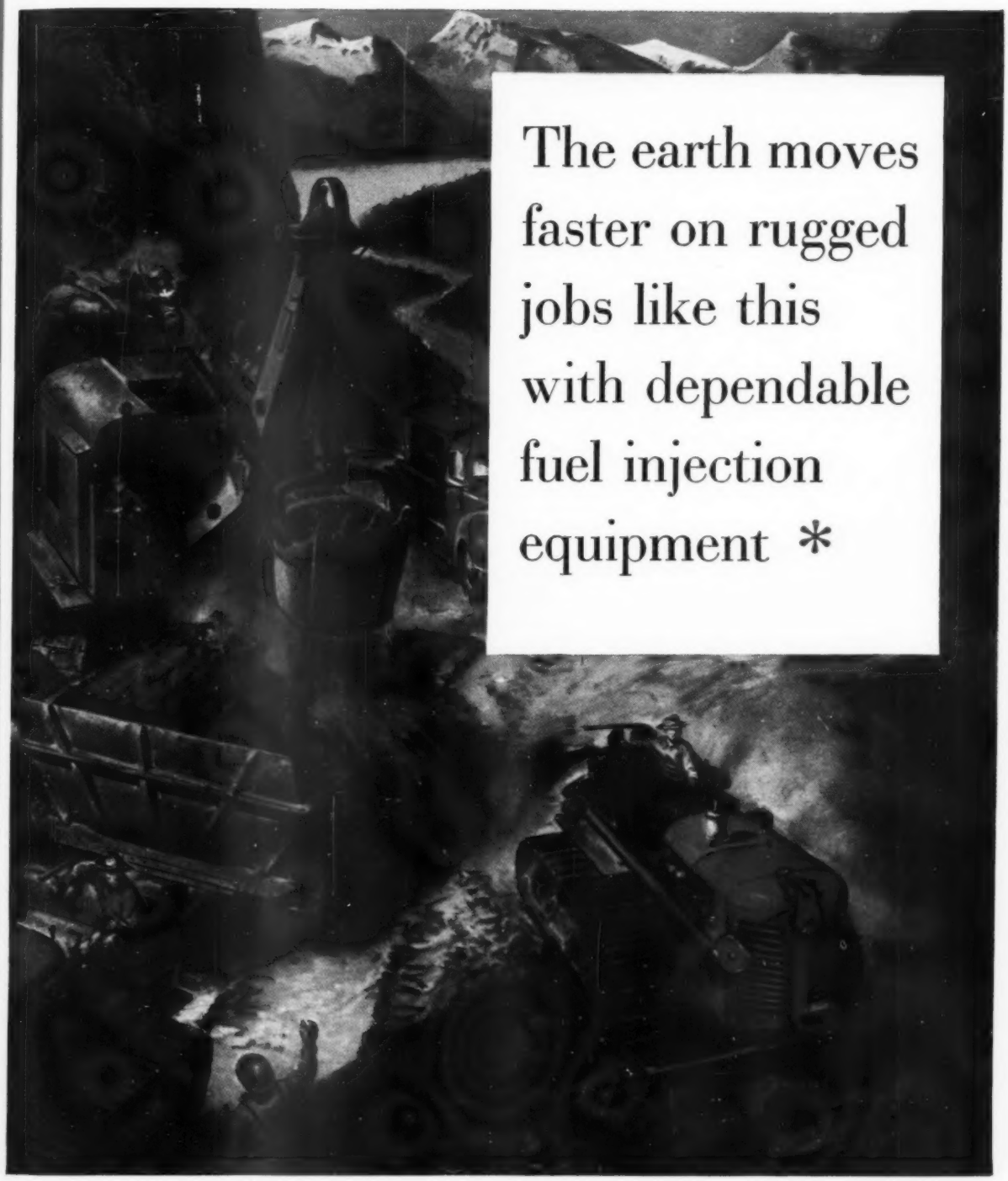


U. S. NAVY PHOTO

**Experimental Gas Turbine** at Annapolis is shown in new building to which it was recently moved. After extensive testing at progressively higher temperatures, the U. S. Navy unit has now been operated in several tests at its design temperature of 1500° F.

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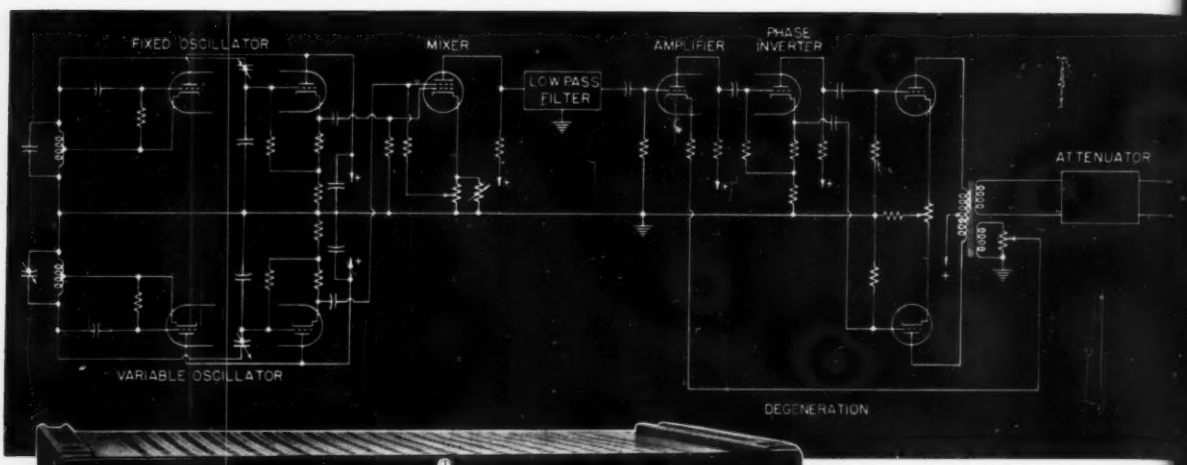

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- **LOW DISTORTION:** harmonic content approximately 0.25% between 100 and 7500 cycles with 0.3 watt maximum output; on HIGH OUTPUT of 1 watt, distortion less than 1% between 100 and 7500 cycles. Below 100 and above 7500 cycles distortion is higher.
- **ZERO BEAT INDICATOR:** neon lamp for zero beat at line frequency or zero scale.
- **FREQUENCY STABILITY:** drift from cold start less than 7 cycles in first hour and completed in 2 hours.
- **OUTPUT IMPEDANCE:** 600 ohms, either grounded or balanced-to-ground, and essentially constant at all output voltages.
- **OUTPUT VOLTAGE:** approximately 25 volts open circuit. For matched resistive load voltage varies less than ±0.25 db between 20 and 20,000 cycles.
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**TYPE 1304-A BEAT-FREQUENCY OSCILLATOR $450.00**

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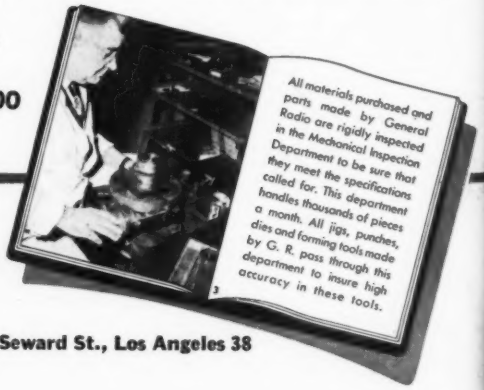
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